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PARACHUTE RIGGER

3 & 2

Volume 2

Prepared by

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

NAVPERS 10359

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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PREFACE

This NAVY TRAINING COURSE is the second in a series written for the purpose of helping enlisted men of the U. S. Navy and Naval Reserve to qualify for promotion to the rates of Parachute Rigger, Third Class and Second Class. It is one of a series of NAVY TRAINING COURSES designed to give men of the Navy the background information necessary to secure advancement in rating. Combined with the necessary practical experience, this training course along with volume 1 will help prepare the reader for the advancement-in-rating examination.

A study guide has been included in this course and reference to it should be made by the personnel striking for PRS and PRM to determine which chapters are pertinent and applicable to their ratings.

The qualifications for Parachute Riggers are listed in appendix II. This training course and its companion, volume 1, contain information on the technical qualifications for Parachute Riggers 3 & 2. Because the examinations for promotion are based exclusively on these qualifications, it is suggested that the strikers and PR3's refer to them frequently for guidance both in using these NAVY TRAINING COURSES and in using the other publications listed in the Reading List.

Volume 1 of this series starts with an introduction to the PR rating. Then attention turns to the types and components of parachutes, inspection, packing and rigging, jumping techniques, and the standard layout of a typical parachute loft. Sewing machines, fasteners, maintenance procedures, and seams are discussed. This volume, volume 2, discusses oxygen, regulators, fittings, systems, masks, and survival equipment. These two courses are not designed as aircraft equipment maintenance manuals and are not to be used as such.

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As one of the NAVY TRAINING COURSES, this course represents the joint endeavor of the Navy Training Publications Center, Memphis, and the Training Division of the Bureau of Naval Personnel. Credit is also given to the Parachute Rigger School at Lakehurst, N. J., for their technical review and for supplying the end-of-chapter questions which review the materials contained in each chapter.

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READING LIST

Parachute Rigger 3 & 2, Vol. 1, NavPers 10358

Safety & Survival Equipment for Naval Aviation, NavAer 00–80T–52

CO_2 Recharge Pump, NavAer 19–1–501

Oxygen Recharge Equipment, AN 19–5–17

Parachute Manual, NavAer 13–5–501

Naval Aircraft Oxygen Equipment Handbook, NavAer 03–50–517

ACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS*	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7A
SERVICE	4 mos. service—or completion of recruit training.	6 mos. as E–2 or 8 mos. total service.	6 mos. as E–3 or 14 mos. total service.	12 mos. as E–4.	12 mos. as E–5; total service at least 36 mos.	36 mos. as E–6.
SCHOOL	Recruit Training.		Class A for PR3, PRS3.		Class B for MN1.	Class B for AGCA, MNCA, MUCA.
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.			
PRACTICAL FACTORS	Locally prepared check-offs.		Records of Practical Factors, NavPers 760, must be completed for all PO advancements.			
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.			
EXAMINATIONS	Locally prepared tests.		Service-wide examinations required for all PO advancements.			
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Required for E–3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed.				
AUTHORIZATION	Commanding Officer		U. S. Naval Examining Center			BuPers
	TARS are advanced to fill vacancies and must be approved by district commandants or CNARESTRA.					

*Recommendation of petty officers, officers and approval by commanding officer required for all advancements.

INACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS*		E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7A
	FOR THESE DRILLS PER YEAR						
TOTAL TIME IN GRADE	24 OR 48	9 mos.	9 mos.	15 mos.	18 mos.	24 mos.	36 mos.
	12	9 mos.	15 mos.	21 mos.	24 mos.	36 mos.	42 mos.
	NON-DRILLING	12 mos.	24 mos.	24 mos.	36 mos.	48 mos.	48 mos.
DRILLS ATTENDED IN GRADE#	48	27	27	45	54	72	108
	24	16	16	27	32	42	64
	12	8	13	18	20	32.	38
TOTAL TRAINING DUTY IN GRADE#	24 OR 48	14 days	14 days	14 days	14 days	28 days	42 days
	12	14 days	14 days	14 days	28 days	42 days	42 days
	NON-DRILLING	None	None	14 days	14 days	28 days	28 days
PERFORMANCE TESTS				Specific ratings must complete applicable performance tests before taking examination.			
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)		Record of Practical Factors, NavPers 1316, must be completed for all advancements.					
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Completion of applicable course or courses must be entered in service record.					
EXAMINATION		Standard exams are used where available, otherwise locally prepared exams are used.					
AUTHORIZATION		District commandant or CNARESTRA					BuPers

*Recommendation of petty officers, officers and approval by commanding officer required for all advancements.

#Active duty periods may be substituted for drills and training duty.

STUDY GUIDE

The qualifications shown in Appendix II at the back of this book include the qualifications for the two newly established emergency service ratings. Since at this time the Selective Emergency Service Rates program is in effect, strikers for third class are required to advance in the emergency service rates. The scope of the emergency service rates are:

1. Parachute Riggers S (Survival), Rating Code No. 7001 Maintain, service, repair, and instruct in use and maintenance of parachutes, carbon dioxide equipment for life rafts, safty belts and shoulder harnesses, cargo assemblies, air-sea rescue equipment, protective clothing, and survival kits.
2. Parachute Riggers M (Maintenance), Rating Code No. 7002.
   Maintain, service, repair, calibrate, and instruct in the operation, use, and care of aviators' breathing oxygen systems, liquid oxygen systems, storage and transfer equipment, servicing equipment, full pressure suits, pressure suit pressure/ventilation controls, composite disconnects, and associated equipment.

This Navy Training Course, Vol. 2 of *Parachute Rigger 3 & 2*, contains materials that are primarily concerned with the qualifications of PRM. Vol. 1 contains mostly materials for PRS's. The Chapter Guide which follows directs the study of the pertinent parts of this course for PR's, PRM's and PRS's.

Chapters	PR	PRM	PRS
1 through 9	X	X	
10 through 13	X		X

PARACHUTE RIGGER 3 & 2

Volume 2

CHAPTER 1

OXYGEN PHYSIOLOGY AND PRINCIPLES OF AN OXYGEN SYSTEM

COMPOSITION OF THE ATMOSPHERE

The purpose of this section is to acquaint the Parachute Rigger with some of the physical aspects of the atmosphere in relation to the human body. When one understands the reasons and importance of properly maintained oxygen equipment, he will be better able to prepare himself for his future specialized duties.

The atmosphere is a mixture of several different gases. A sample of dry air contains about 78 percent (by volume) nitrogen, 21 percent oxygen, and about 1 percent argon. In addition, it contains about 0.03 percent carbon dioxide and minute amounts of other gases. The air also contains a variable amount of water vapor. The maximum amount of water vapor that the air can hold depends on the temperature of the air; that is, the higher the temperature, the more water vapor it can hold (never more than about 4 percent by volume).

The depth of the atmosphere is calculated to be approximately 1,000 miles (texts quite often differ on this point), and may be considered a part of the earth. The earth does not rotate within the atmosphere, but rather, the atmosphere rotates with the earth held to its surface by gravity.

The atmosphere is divided into concentric layers. Closest to the earth is the layer known as the troposphere. Next are the stratosphere, ionosphere, and exosphere. The troposphere varies in thickness from the Equator to the poles; its vertical extent is greatest over the Equator (60,000 feet

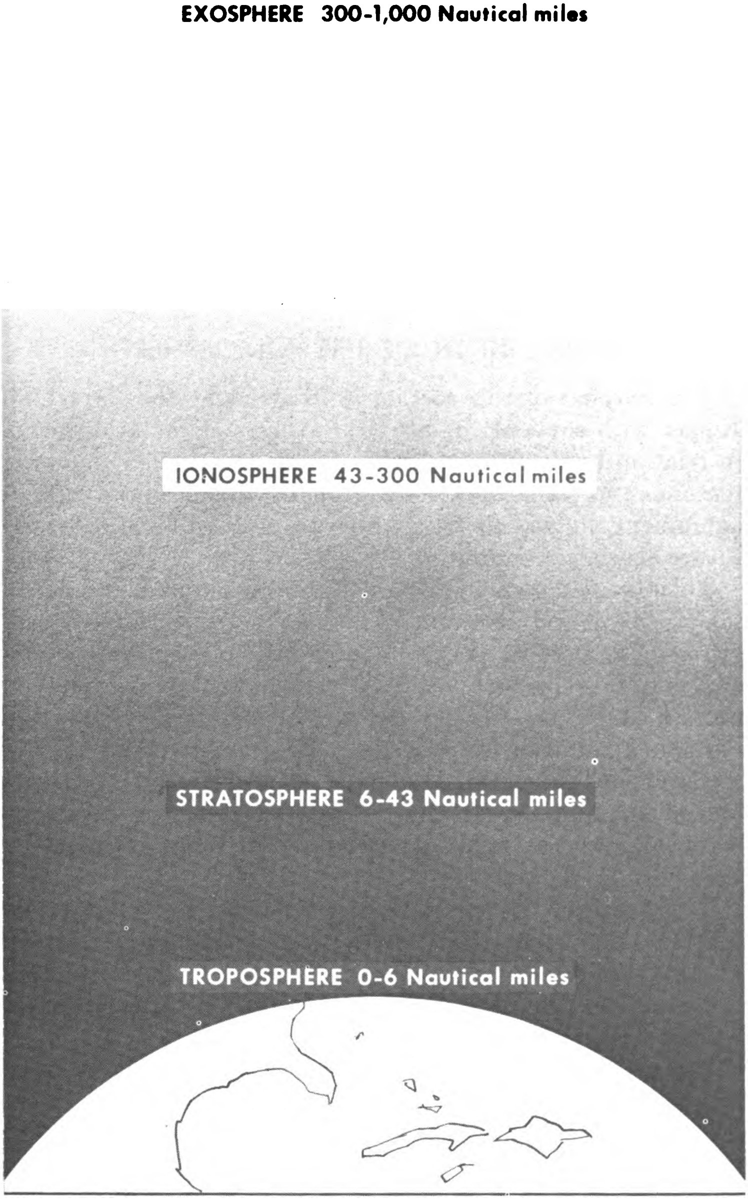
EXOSPHERE 300-1,000 Nautical miles
IONOSPHERE 43-300 Nautical miles
STRATOSPHERE 6-43 Nautical miles
TROPOSPHERE 0-6 Nautical miles

Figure 1-1.—Divisions of the atmosphere.

above sea level) and least over the poles (30,000 feet above sea level). This variation is due to the fact that the greater temperature in the region of the equator causes the air to be less dense and requires a greater volume, or tropospheric height, than at the poles where the cold air is very dense. The boundary between the troposphere and the stratosphere is referred to as the tropopause. (See fig. 1-1.)

TEMPERATURE.—The variation of temperature in the atmosphere is as follows:

1. From the ground up to about 35,000 feet, the temperature normally drops at the rate of approximately 3½° F. per 1,000 feet of altitude. By 10,000 feet, the temperature has dropped 35° F. below ground temperature; at 20,000 feet it has dropped to 70° below ground temperature; and by 35,000 feet the temperature is 126° F. below that existing on the ground. Normally, we speak of a STANDARD ground temperature, 59° F., which is the representative average temperature on the surface of the earth at U. S. latitudes. Consequently, the temperature at 35,000 feet is generally taken as being 126° F. below the standard ground temperature, or −67° F.
2. From 35,000 to 150,000 feet, the air stays at about −67° F.
3. Above 150,000 feet a region of extremely high temperature begins.

DISCOVERY OF OXYGEN.—The history of the discovery of oxygen, less than two centuries ago, is interesting. Joseph Priestly, an English clergyman who came to the United States to live, experimented a great deal with gases. On August 1, 1774, when heating a glass tube of mercuric oxide, a red powder, he noticed a silvery mirror forming on the cold portions of the tube. This he recognized as mercury. But a colorless gas was also escaping. What might the gas be? A lighted candle, when plunged into the gas, burst in a glaring flame. A mouse, when put into a glass jar with the new gas seemed to become more frisky. Priestly felt braced when he inhaled the gas. Priestly thus is given the credit for discovering oxygen; although a Swedish chemist, Karl Scheele, actually had found it two years before him. Priestly, however, did not know about it and he was the first who made the discovery public.

ATMOSPHERIC PRESSURE

Although extremely light, air has weight and is highly elastic and compressible. Because of its weight and density, the atmosphere exerts a certain pressure. The amount of pressure it exerts upon the surface of the earth at sea level is 14.7 pounds per square inch (p. s. i.). Its molecules press in all directions at the same time; and this makes it possible to measure its pressure by several different means.

As one ascends higher into the atmosphere, it becomes less dense and colder. (Study fig. 1–2.)

MEASURING ATMOSPHERIC PRESSURE.—Measurement of atmospheric pressure is accomplished by use of a barometer. This is a sensitive instrument responding to the pressure exerted by the molecules contained in the air. In its simplest form a cup or cistern barometer consists of a gradu-

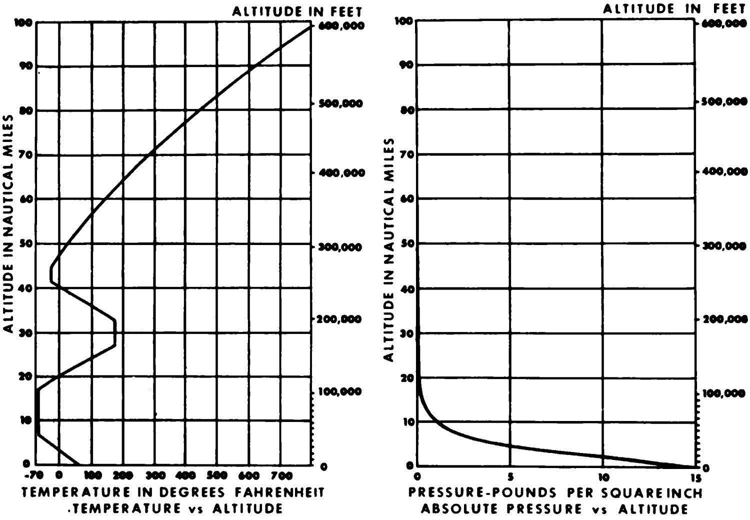

Figure 1–2.—Atmospheric pressures and temperatures at various altitudes.

ated glass tube filled with mercury and inverted in a cup containing mercury. The height of the column of mercury in the tube varies in response to changes in atmospheric pressure.

An aircraft altimeter is, in a sense, a barometer calibrated in feet instead of inches, operating on the same principles of measurement, but using an aneroid (vacuum sealed metallic bellows) instead of mercury in a glass tube. A pointer connected through linkage with the aneroid of an aircraft altimeter registers the altitude on the face of a dial. Observance of the altitude is mandatory to the well-being of all those who fly in aircraft.

Partial pressure of oxygen.—The decrease in pressure with altitude has effects of the greatest importance upon one's ability to function as a pilot or crewman. Since oxygen composes only 21 percent of the atmosphere by volume, it is considered as having a partial pressure value of approximately 3 p. s. i. at sea level. This partial pressure is often referred to as being necessary to the sustenance of life, which incidentally is true, when we consider the density and weight factors involved in all types of gases. Anything that has mass has weight; and like liquids, certain kinds of gases will flow or be absorbed more readily than others. In direct relation to the last statement it can be said that it takes a required amount of pressure to force a liquid or gas through a restricting member like a filter or a membrane. Three pounds of partial oxygen pressure is sufficient to force oxygen into the blood stream.

At 18,000 feet the atmospheric pressure registers a mere 7.35 p. s. i. as compared to 14.7 p. s. i. on the ground. Remembering that oxygen comprises ⅕ by volume of the atmosphere, we can easily see that the oxygen pressure of approximately 3 p. s. i. is reduced to approximately 1.50 p. s. i. or half the pressure required in the lungs to supply the blood with oxygen. Therefore, it is apparent that, as we gain in altitude, we must provide ourselves with some artificial means to retain the vital 3 p. s. i. of oxygen pressure. This is accomplished by means of an oxygen system built into the aircraft.

BREATHING OXYGEN

Physiology deals with the processes, activities, and phenomena of life and living organisms. It is the study of the functions of the organs and parts during life, as distinct from anatomy. Oxygen physiology deals with the same subjects, but more directly with the effects of oxygen, or the lack of it, on the human body.

The purpose of breathing is to get oxygen into the blood stream and carbon dioxide out. This exchange is made through the walls of millions of tiny sacs and blood vessels in the lungs. The importance of this function may be judged from the total surface of these sacs, estimated to be between 700 and 800 square feet, or 40 to 50 times the skin surface of the body. The walls of the sacs are thin, moist, and porous, thus enabling oxygen to be pushed through this barrier. Oxygen is also pushed through small tubes in the walls of the tiny blood vessels surrounding each sac. These tiny tubes connect with a large artery which carries blood from the heart to the lungs and with veins which carry the blood back to the heart. The heart pumps blood throughout the body where oxygen burns the food, making the heat needed to keep the human machine going.

The blood carries oxygen in the red blood cells or solid substance of the blood. These cells carry oxygen at about 95 percent of their total capacity, which is about a pint of oxygen in every five pints of blood. The red cells pick up oxygen easily at ground-level atmospheric pressure, such as is found in the lung sacs, and release it quickly at lower pressures, such as are found in the body's tissues. As oxygen is released, the waste carbon dioxide is picked up and returned to the lungs, where it is exhaled into the air. Figure 1–3 illustrates how oxygen is admitted and distributed throughout the human body, and how carbon dioxide (CO_2) is expelled.

Oxygen in Relation to Altitudes and Breathing

USE OF OXYGEN IN HIGH ALTITUDE FLYING.—In the combat operations of the Air Force during World War II, more than 200 fliers died from the lack of oxygen. An estimated 11,000

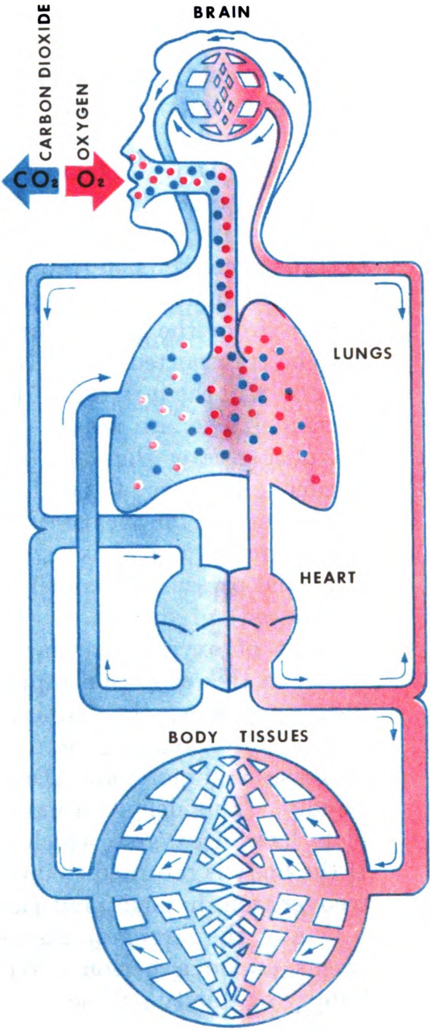

Figure 1–3.—Circulatory system of the human body.

more became unconscious for the same reason, but were revived by crewmembers who restored their oxygen supply and, on some occasions, applied artificial respiration.

Remember that the higher the altitude, the less the pressure. The less the pressure, the less oxygen in the blood. The less oxygen in the blood, the effect on the body becomes worse. The longer all this continues, the more the effects of oxygen deficiency increase.

Present directives state that oxygen shall be used on ALL flights when the aircraft altitude exceeds 10,000 feet above sea level. (Above 10,000 feet the air pressure is reduced, and cannot force a sufficient quantity of oxygen into the blood stream.) Oxygen shall be used on all night flights when the altitude exceeds 5,000 feet. (Increased oxygen consumption improves night vision, and many squadrons start using oxygen from the ground up.) Passengers without oxygen may be transported above 10,000 feet, and as high as 12,000 feet, only in the interests of flight safety. (Inactive airborne personnel who are seated in restful positions can survive altitudes greater than 10,000 feet for short periods without ill effects; however, 10,000 feet should not be exceeded unless it is necessary for the safety of all those concerned.)

EFFECTS OF THE LACK OF OXYGEN.—The result of a decrease in partial pressure (occurs if the overall atmospheric pressure is reduced) of oxygen in the air results in an insufficient amount of oxygen entering the blood stream. The body reacts to this condition rapidly. As ascent into the atmosphere increases, the partial pressure of the oxygen—the driving force tending to push it into the blood stream—decreases still more, and the lack of oxygen is felt even more rapidly. This deficit in oxygen is called HYPOXIA. A complete lack of oxygen, which causes death, is called ANOXIA. If the body is returned to its normal oxygen supply, one may recover from hypoxia, but cannot recover from anoxia.

One of the strangest things about hypoxia is the way it creeps up on a person. Without water or food one gets hungry or thirsty—these are the warning signals sent out by the body to indicate it is time to refuel. When the oxygen supply is being cut down, little or no warning is received.

It is one case where nature did not provide an adequate warning system.

One of the earliest and most striking effects of hypoxia is a loss of vision—not a total loss, but a decrease in ability to see clearly. The loss of vision is due to the fact that the brain is affected by a lack of oxygen before other parts of the body. The eyes which are usually thought of as part of the brain are, therefore, among the first of your senses to show the effects of the lack of oxygen.

When the brain is deprived of oxygen, the ability to concentrate and memory of recent events are lost. Since the brain is the first organ affected, everything else fails.

Perhaps you have thought that one way to obtain more oxygen would be to breathe faster. This is true as more oxygen is absorbed into the blood stream, but it will cause unconsciousness if rapid breathing is continued too long.

By breathing more rapidly, the carbon dioxide in the blood stream, which controls the rate of breathing, is eliminated more rapidly. It is not the fact that the body needs more oxygen that causes breathing to become deeper or more rapid, but it is due to the effect of carbon dioxide which must be expelled from the lungs. If too much carbon dioxide is eliminated, strange sensations will be experienced. Dizziness will occur and spots will appear in front of the eyes. The fingers and toes will get numb and eventually may even become paralyzed.

Let the amount of carbon dioxide in your blood do the thinking for you. NEVER FORCE YOUR BREATHING!

EFFECTS OF THE LACK OF PRESSURE.—An oxygen deficiency is not the only thing that can happen to a person when ascending into the upper limits of the atmosphere. During ascent the gas in various cavities of the body expands because of lowered atmospheric pressure and can cause trouble if it gets trapped there with no means of escape. According to Boyle's law, gas expands or contracts in proportion to the pressure applied. A crewman in good physical condition is far less susceptible to any kind of air sickness than one in poor condition. Once altitude sickness sets in, the only remedy is to descend at once to a safe altitude.

OXYGEN

Characteristics

Oxygen is a colorless, odorless, tasteless gas, somewhat heavier than nitrogen and slightly soluble in water. Oxygen is considered to be the most important of all 96 elements. It forms about 23 percent of the atmosphere by weight and 21 percent by volume. Its chemical symbol is O and atomic number is 8.

Of all the elements in the universe, oxygen is the most plentiful. It makes up nearly one-half of the earth's crust and approximately one-fifth of the air.

Lavoisier, a French chemist, was the first to recognize the immense role played by the new gas in nature. He named it OXYGEN because he believed that it was part of all acids (OXYZ in Greek). It is now known that this is not entirely true, but the name has remained.

To understand the greatness of Lavoisier's discovery one must know how scientists before him explained burning. They believed that every combustible matter (a matter that can burn) contained an imaginary substance which they called phlogiston. This was supposed to escape during combustion (burning). The redder a matter burned the richer it was thought to be in phlogiston. Thus, metals were thought to have some phlogiston in them. Coal was thought to be rich in it, and hydrogen very rich, almost all phlogiston. Water, which forms when hydrogen is burned, was thought to be hydrogen which had lost all its phlogiston. The idea of phlogiston explained a great many things at that time. But it was soon discovered that when a metal was burned it actually weighed more than before. After that it was difficult for believers in phlogiston to explain how a metal could become heavier when its phlogiston had escaped.

Having learned of Priestley's discovery and description of the new gas, Lavoisier's quick mind immediately grasped the true nature of combustion. Lavoisier recognized that burning is nothing else but chemical union of the elements of the burning matter with oxygen. He proved it by many clever experiments. For example, he showed that when mercury burns it swallows up the oxygen in the air. What is more, the red powder obtained was heavier than the mercury by exactly the weight of the oxygen swallowed. Therefore, the true nature of combustion was recognized, and the whole idea of phlogiston was dropped.

Oxygen eagerly combines with most elements. Combinations of an element with oxygen is called OXIDATION. The compound with oxygen is called OXIDE. Thus, in Lavoisier's experiment mercury was oxidized, the red powder obtained was mercury oxide. Water is the oxide of hydrogen. Combustion is simply fast oxidation. In almost all oxidations heat is given off. In combustion the heat is given off so fast that it does not have time to be carried away; the temperature rises extremely high and a flame appears.

Slow oxidation caused by the oxygen of the air, such as rusting of iron, drying of paints, and the changing of alcohol into vinegar, are a few examples. Some oxidations are beneficial; others, such as rusting, are harmful. Even fuels in storage are slowly oxidized but the heat is usually carried away fast enough; however, when the heat can not easily escape, the temperature may rise dangerously and a fire will break out. This is called SPONTANEOUS COMBUSTION.

Oxides are present everywhere, in rocks, in minerals, and in the soil. Only air is not an oxide, but a mixture of oxygen and nitrogen. Oxygen is one of the main elements of most organic compounds and all those of which living bodies are built.

Compressed Oxygen

All oxygen used for aviation purposes is manufactured by the FRACTIONAL DISTILLATION METHOD, that is, to boil liquid air. Air is a mixture chiefly of nitrogen and oxygen and can be made liquid by cooling to a low temperature (more than 300° below zero F.). When liquid air warms up a little above that temperature, it boils; nitrogen boils off first and oxygen remains.

Another method of making oxygen is by ELECTROLYSIS (electric splitting or decomposition) of water. When an electric current is passed through water, pure oxygen escapes at the anode and hydrogen at the cathode.

To compress pure oxygen obtained by the above methods, it is directed through a compressing machine which pumps and compresses it into a container.

Compressed oxygen is very dangerous, and must be handled very carefully so as to prevent an explosion. There are often disastrous results when compressed oxygen is brought in contact with any hydrocarbon. A hydrocarbon, chemically speaking, can be gaseous, liquid, or a solid compound of carbon and hydrogen, which is insoluble and combustible. Some 200,000 hydrocarbon derivatives are known; among them are gasoline, grease, oil, and natural gas. So, NEVER PERMIT OIL, GREASE, AND OTHER HYDROCARBONS TO COME IN CONTACT WITH COMPRESSED OXYGEN. There is little consolation in the fact that oxygen by itself is not explosive since the cause of an explosive action is effected by compressed oxygen coming in contact with burnable materials.

Types and Grades of Oxygen

Oxygen is manufactured in two grades, A and B. A water vapor content is specified for grade A but not for grade B. Oxygen, permitted to gas off from its liquid state, is delivered for use as a type I gas; but in its liquid state it is termed type II liquid. Both grades of oxygen are 99.5 percent pure by volume of gas (dry basis).

The water content of cylinders dried in the baking ovens cannot exceed 0.02 milligram per liter. That is practically bone dry, and will suffice as an explanation for the extreme precautions taken to keep oxygen containers free from the water vapor found in the air.

These precautions are not taken to avoid a physical injury to the body. We can breathe air containing a high percentage of humidity indefinitely without any serious ill effects. The moisture problem affects the aircraft oxygen system in the minute orifices of the regulator. Freezing temperatures can clog the system with ice and prevent oxygen from reaching the pilot or crewman. Extreme precautions must be taken to safeguard against this water vapor hazard as you will learn later.

All the oxygen used in aviation is manufactured by the fractional distillation method as previously described under "Compressed Oxygen." No toxic or odoriferous material can be used to clean any of the oxygen processing equipment. It must be kept immaculate! Only a very few cleaning agents are approved for use around oxygen equipment. Cleaning agents cannot contain any hydrocarbons that will leave a residue film or odor which later will come in contact with oxygen. Always remember that, and be certain of it before applying a drop of any foreign substance to oxygen equipment.

Type I grade A oxygen and type II oxygen are intended for use in aircraft breathing equipment without further drying. No other grades and types are to be used as AVIATOR'S BREATHING OXYGEN.

There are many technical uses for oxygen which need not be manufactured to rigid purity specifications and very low water vapor content. Technical oxygen is widely used for hot flame in hydrogen and acetylene torches for welding and cutting metals.

Hospitals use oxygen to make breathing easier for patients whose lungs are weak from illness. The water vapor content is not important here, but the purity is; however, to be on the safe side many hospitals often use the same grades as specified for aviator's breathing oxygen.

Procurement for Service Use

Any system of procurement raises the question of measurement—quantity in some unit of measure; therefore, knowledge of the unit of issue is essential. Gas is measured or metered by containing and passing it through a series of tubing and a gas meter. The meter registers the VOLUME of gas passed through it in CUBIC FEET (cu. ft.). Thus, the unit of measure for gas is the cubic foot, and therefore oxygen is purchased by volume in units of cubic feet. Cost varies depending upon source of supply, often fluctuating between 0.006 and 0.009 cent a cubic foot when it is purchased commercially. One cubic foot equals 1,728 cubic inches.

Oxygen gas is contained in heavy cylinders of varying capacities, size being determined by the intended operational use of the gas. All the cylinders are shaped along the same general contours, except the large capacity storage cylinders which are flattened and indented at the bottom to facilitate their standing in an upright position. Aircraft supply cylinders, used in an oxygen system, are smaller than the storage type and are rounded at the bottom. These must be laid on their sides when not in use, and must be bracketed in place when installed.

Liquid oxygen, which gases off as it warms up, is stored in large tanks of various forms. Aircraft liquid oxygen supply tanks are often ball-shaped and, like the gas cylinders, are much smaller than the storage tanks. The use of liquid oxygen in naval aircraft oxygen breathing systems is at present limited, but it will eventually replace the use of gaseous oxygen.

Liquid oxygen is obtained by a combination freezing and pressurization process of pure oxygen in its gaseous state. When the gas temperature is lowered to —182° F. under about 2,000 p. s. i., it will begin to form into a liquid. When it reaches —297° F., it will remain a liquid without pressurization, other than normal atmospehric pressure. Once converted into a liquid, oxygen will remain in its liquid state as long as the temperature is maintained at or below —297° F. It will remain a liquid under pressure until warming to —182° F. Then no amount of pressure will prevent it from reverting to its gaseous state.

Liquid oxygen is pale blue in color and weighs 9.6 pounds per gallon. The ratio of the volumes of liquid oxygen and gaseous oxygen at standard temperature and pressure (0° C. and sea level atmosphere) is 1 to 856.

The Navy has installed LIQUID OXYGEN PLANTS on many of its aircraft carriers as well as its outlying bases. The necessity for adopting its own on-the-spot oxygen generating plants was brought about by the jet age and the numerous extended high altitude flights of the Navy's jet aircraft. The initial high cost of an oxygen generating plant is quickly justified when we comprehend the relief that such a system affords to the arteries of supply. However, a great percentage of oxygen gas is still obtained through supply department open purchase methods, under contract with local commercial gas industries. The companies charge or fill the government-owned oxygen storage cylinders and deliver them directly to the supply department. Whereupon the supply department issues and charges the gas off as a general stores bulk stock item. The old standard storage cylinder holds 200 cubic feet of oxygen, compressed to 1,800 p. s. i. More highly compressed bulk oxygen, used for refilling aviator's small breathing cylinders, replaces the older standard 200-cubic foot cylinder. These stronger and larger storage cylinders will not be procured until 2,265 p. s. i. 250-cubic foot cylinders are stocked to replace stocks of 1,800 p. s. i. cylinders. Use of larger capacity oxygen gas cylinders will increase the number of aircraft supply cylinders that can be fully charged (without the use of a compressor), as compared with the older type of less capacity.

To obtain a supply of oxygen gas an empty cylinder of equivalent size and type should be returned for exchange. When an exchange cylinder is returned, the requisition should specify the stock number shown under the subhead "Gas" and corresponding to the size of the cylinder involved. When an empty cylinder is not available for exchange, the request should specify both the stock number under the subhead "Gas" and the stock number under the subhead "Empty Cylinder" for the desired size cylinder. The cylinder will be charged with the gas, and the cost of the gas cylinder will be invoiced to the requisitioning activity.

Testing Oxygen

Since the purity and the water vapor content of aviator's breathing oxygen is so important to its being used successfully at high altitudes, it must be subjected to on-the-spot periodic ground tests. Impure oxygen is dangerous at any altitude. Its water vapor content becomes dangerous when the temperature is low enough to freeze the droplets in an oxygen system. Past experience has proven that it is impossible to conduct too many tests in determining that aviator's breathing oxygen is safe for use.

CHLORINATED HYDROCARBON CONTAMINATION.—Aviator's breathing oxygen storage cylinders, regardless of source, and aircraft oxygen cylinders SHALL BE TESTED for chlorinated hydrocarbon contamination prior to their release for breathing purposes in aircraft. After a satisfactory completion of the test a distinguishing tag or decal shall be applied to each cylinder tested, giving the date of the test, place, and name of the individual conducting it, and a statement that the cylinder tested does not contain any hydrocarbons as evidenced by no change in the color of the flame. This test is performed by qualified Parachute Riggers (First Class and above) with a Halide detector. However, Parachute Riggers of a lower rating are responsible for recognizing the appropriate cylinder marking (tag or decal) which indicates that a Halide test has been conducted on the applicable oxygen cylinders.

Untagged aircraft oxygen cylinders installed in aircraft and any untagged aircraft oxygen cylinders received from supply departments must be tested and tagged. Repetition of this test on previously tested and tagged aircraft oxygen cylinders is not required in the field provided recharging is always conducted from tested and tagged aviator's breathing oxygen storage cylinders.

Test tags shall not be removed from aircraft oxygen cylinders and aviator's breathing oxygen storage cylinders until the need for retesting arises, at which time the old tag shall be replaced with an appropriate new one. This new tag shall give all the necessary identifying information relative to the place, date, individual making the test, and the statement that the particular cylinder does not contain chlorinated hydrocarbons as evidenced by the type of instrument used. An example is as follows:

Type of test	Chlorinated hydrocarbon
Place	NAS, Memphis, Tenn., Operations Department
Date	11 May 1955

Tested by----------- John W. Smith, PR1
Result-------------- This cylinder was Halide tested using an approved acetylene type tester on the date listed above. No trace of chlorinated hydrocarbons could be identified, as the blue flame characteristic of this testing device did not change color.

All cylinders shall be retested when the test tag is lost or permanently removed for any reason. All oxygen cylinders shall be retested when contamination of the oxygen system occurs or is suspected.

All aircraft oxygen cylinders shall be retested when the aircraft in which they are installed are overhauled.

Inspect all aircraft oxygen cylinders during AIRCRAFT ACCEPTANCE checks for compliance with the last statement.

Water vapor tests and other purity tests may be conducted by experienced Parachute Riggers after they have attended and successfully graduated from the appropriate school.

Safety Precautions

Compressed oxygen and any inflammable substance can unite with explosive results, the extent of this danger depending upon the conditions of concentration, pressure, temperature, and confinement. The main ingredient for spontaneous combustion lies in the attainment of a burning temperature. (The temperature at which a material will burn.) Applied concentrations of pure oxygen in an enclosed area where burnable material is present will result in an explosion. Danger exists in the accumulation of heat when the heat of a rapidly oxidizing hydrocarbon is unable to be carried off normally. This condition generates an excessive amount of heat which is capable of bursting into flame with great force and heat, depending on the kind of material affected and its area of confinement.

Oxygen while not inflammable in itself is the principal supporter of combustion; and since concentrated or pure oxygen greatly intensifies burning or the oxidation of any hydrocarbon, it is easy to understand the seriousness of the situation when the oxygen pressure is increased. Certain hydrocarbons are naturally more susceptible to burning than others; and when pressurized oxygen gas is carelessly sprayed on quantities of volatile liquids or paste, the reaction is one of accelerated oxidation. The oxidation is accelerated at such a tremendous rate that the flashpoint of the material is reached almost instantly, and an explosion equal to the energy of TNT results.

KEEP OIL AND GREASE AWAY FROM OXYGEN AND OXYGEN EQUIPMENT. This is the primary rule to remember. It implies every conceivable precaution to be taken when a man is working in the shop or in an airplane. Sometimes danger is not apparent until a badly flexed and weakened high-pressure line breaks while transferring oxygen in the fuselage of a dirty and oily aircraft. Look for a place where oil and grease may accumulate or collect, and take remedial action to prevent its coming in contact with oxygen. In working with oxygen, it is easy to overlook troublesome areas and become careless. Either keep the filler lines clean and clear or keep oxygen away from such lines.

A list of general safety precautions follows:

1. When attaching an oxygen transfer line to an aircraft system, always make certain the connections are clean, dry, and in good condition before cascading or pumping oxygen.
2. When cascading or pumping oxygen into a system, have someone standing by who can positively shut off the flow in the event of an emergency.
3. Handle cylinders carefully and never drop or bump them.
4. Never use cylinders as rollers for moving heavy equipment.
5. Do not drag or slide cylinders across a deck or the ground.
6. Never mix oxygen with other gases.
7. Never purge an aircraft oxygen system with any gas other than bone-dry water-pumped air or nitrogen. After purging always charge the system with pure oxygen, testing it for odor.

8. Never completely expend the supply of oxygen from a cylinder. Always leave a residual pressure in excess of 15 p. s. i.
9. Do not leave oxygen cylinders near any extreme source of heat.
10. Never fill a lower pressure capacity cylinder without an approved pressure reducing valve.
11. Never use any piece of equipment before understanding its purpose and use.
12. Always check the latest hydrostatic test data stamped on the neck of a cylinder.
13. Always check to make certain the cylinder has been tested for chlorinated hydrocarbons.
14. Never overfill a system.
15. Never leave a trailer cascading system turned on after use.
16. Never leave filling connections exposed to the weather.
17. Never set a filling connection down on the deck or ground.
18. Once pressure is on a flexible filling line never let go of it.
19. Always replace protective thread and end-of-line caps.
20. Never use oxygen filler lines for any gas other than pure dry oxygen, nitrogen, or water pumped dry air. (Water pumped air does not contain the slightest trace of oil or grease, and is usually more difficult to obtain than the nitrogen.)
21. Never use anything but an approved cleaning agent for cleaning external oxygen fittings.
22. Never permit the use of electromagnets in handling oxygen cylinders..
23. Never hoist oxygen cylinders with rope or chain slings. Handle with cranes and specially built cradles, using cable straps to protect them from shifting.
24. When transporting in trucks, storage cylinders should be securely fastened together in an upright position.
25. Protect stored cylinders from excessive temperatures. (Maximum temperature 130° F.)
26. Protect cylinders from the direct rays of the sun.

27. In winter protect cylinders from snow and the formation of ice.
28. Keep cylinders away from inflammable materials.
29. Store empty cylinders separately from the full cylinders.
30. Tag or mark empty cylinders. Cylinders are considered empty when less than 50 p. s. i. of pressure remains.
31. Always replace protective valve caps on storage cylinders when they are not in use.
32. Never use greasy rags or wear greasy clothes, or cosmetics (hair oil, lip salve etc.), when working around oxygen equipment.

There are a number of additional safety precautions to be observed when handling liquid oxygen. Some of these parallel the safety precautions outlined for the handling of gaseous oxygen; however, they are worth repeating to insure against accidents. Any possible danger that may occur is based on those general characteristics of liquid oxygen. First, the rate of combustion of most materials can be greatly increased by liquid oxygen; second, contact with liquid oxygen (—297° F.) can cause severe frostbite and damage to equipment vulnerable to freezing conditions; and third, liquid oxygen, if confined, will eventually evaporate and build up a tremendous pressure which could result in the rupture of the tank in which it is stored. Because of these possibilities, the following safety precautions must be observed:

1. Storage tanks must not be located in the vicinity of gasolines, oils, or any other combustible materials.
2. Smoking will not be permitted for anyone working around liquid oxygen.
3. Oil is not to be used near liquid oxygen equipment where it could possibly come in contact with oxygen itself.
4. Allow for free ventilation in any building in which a storage container is located so that a highly concentrated atmosphere of oxygen will not develop.
5. Do not permit liquid oxygen to flow or become trapped

on anything that has oil, fuel, or other combustible materials on it. Also, liquid oxygen should not be permitted to flow near fires, sparks, or other open sources of heat.

6. Do not handle tubes and fittings through which liquid oxygen is flowing with the bare hands.
7. Do not permit liquid oxygen to flow onto any part of the body, clothes, pockets, cuffs, and the like, where it might be trapped.
8. Always be sure that hoses and fittings are dry and clean before allowing liquid oxygen to flow through them. Fittings with moisture on them become frozen in position and cannot change or separate without damage.
9. Do not use rubber hose to transfer liquid oxygen as such hose becomes hard and brittle.
10. Keep the vent valve partially open when the tank is not used to deliver liquid oxygen for some time.
11. When the tank is being filled, be sure that the valve vent is open. Saturated liquid oxygen expands as the pressure is increased and might rupture the tank if it is filled to more than its designed capacity.
12. Disconnect filling or transfer line as soon as the transferring process is completed.

CYLINDERS

Types and Sizes

High-pressure cylinders used in high-pressure permanent aircraft installations are designed to contain a sufficient volume of oxygen in comparison with the average flight duration characteristics of the aircraft. These cylinders are termed AIRCRAFT OXYGEN SUPPLY cylinders and are manufactured in the following sizes:

1. 514 cubic inches internal volume.
2. 295 cubic inches internal volume.

Low-pressure cylinders used in permanent aircraft systems are not as heavily constructed as their nonshatterable high-pressure counterparts, and must therefore hold a greater volume of oxygen in order to provide an equal duration of use. The use of these cylinders in naval aircraft is very limited.

The following types and sizes are used:

1. D–2, 500 cubic inches internal volume.
2. F–1, 1,000 cubic inches internal volume.
3. F–2, 1,000 cubic inches internal volume.
4. G–1, 2,100 cubic inches internal volume.
5. J–1, 18,000 cubic inches internal volume.

High-pressure portable cylinders are constructed the same as permanent types. Since the portable cylinders must be carried around in an aircraft, they are usually smaller in capacity than the 514-cubic inch size. Any size high-pressure aircraft supply cylinder can be rigged for portable use, but the most commonly used are as follows:

1. 92–96 cubic inches internal volume.
2. 205 cubic inches internal volume.
3. 22 cubic inches internal volume (bail out).

Not all low-pressure portable cylinders are similarly constructed as those used in a fixed or permanent system. Walkaround cylinders are lightly constructed and some may by easily fastened to the clothing. The types and sizes are:

1. A–4, 104 cubic inches internal volume.
2. A–6, 280 cubic inches internal volume.

Liquid Oxygen Converters

The 8-liter liquid oxygen converter (tank included) is used to store liquid oxygen in the fuselage of aircraft. The Douglas-type 8-liter converter weighs 36 pounds empty. Its capacity is 20 pounds of liquid oxygen. The liquid oxygen container is a vacuum sealed tank and keeps the liquid oxygen in its liquid form by maintaining it at a temperature of −277° F. Liquid oxygen flows out of the tank into the warming coils. After the liquid oxygen has passed through about two feet of the coil, it is warmed sufficiently to revert to its gaseous state. In the transformation to a gas, the liquid oxygen expands and creates pressure in the system.

Operating Pressures

The ultimate operating pressure for high-pressure aircraft oxygen sypply cylinders is 1,800 p. s. i., and any system will continue to function as long as the oxygen pressure remains above atmospheric pressure. To safeguard against moisture forming in a completely expanded cylinder, an operational empty limit of 300 p. s. i. has been established.

If possible, the pilot should descend to an atmospheric level where additional oxygen is not needed when pressure in the oxygen system drops to 300 p. s. i. Only 1,500 p. s. i. is considered when figuring time in terms of the duration on an oxygen supply.

Low-pressure cylinders operate on a top pressure of 400 p. s. i., while the operation empty figure is set at 50 p. s. i.

A liquid oxygen system (Douglas-type) supplies oxygen, in gaseous form, at a constant pressure of 70 ± 5 p. s. i. to the regulators. The converter is designed so that the liquid oxygen turns back to gaseous oxygen while traveling through the warming coils around the storage tank.

Markings

High-pressure oxygen cylinders are painted green and are stenciled in white letters, AVIATOR'S BREATHING OXYGEN, NONSHATTERABLE. All high-pressure cylinders are nonshatterably constructed to safeguard against explosive shrapnel effects in the event one is struck by gunfire or bursts due to an extreme pressure buildup which has not been offset by operation of the safety valve. Additional information stamped in the metal is located on the shoulder of all cylinders.

Low-pressure oxygen cylinders are painted yellow with the exception of the A–4 walkaround unit which is painted green. Pertinent information relative to the type, internal volume, pressure, and capacity is stenciled in black lettering on the shoulder and/or side of all low-pressure cylinders in addition to the basic marking, BREATHING OXYGEN—NONSHATTERABLE. Many older cylinders still remain in service which are not as completely marked. The size can be checked by referring to dimensional measurements listed in applicable technical publications.

Storage Cylinders

All storage cylinders supplying bulk oxygen for smaller aircraft supply cylinders are the high-pressure type. In accordance with the latest methods, storage cylinders are painted green and are stenciled with white letters, AVIATOR'S BREATHING OXYGEN, NONSHATTERABLE. These cylinders also have a white band around them. Older ones are marked with two white stripes, on opposite sides, running the length of the cylinders. The white stripes identify the older cylinder as nonshatterable. The required stampings located on the shoulder of a storage cylinder provide additional information.

The basic information for identifying the many types and sizes of oxygen cylinders used in naval aviation has been given in this section to acquaint the reader with a fundamental understanding of the methods employed to contain oxygen gas. From this, one can fully appreciate the extreme care a maintenance man must exercise in choosing the right container (cylinder) for the proper installation. More detailed information and illustrations of each type oxygen cylinder will be discussed in chapter 8.

PRINCIPLES OF AN OXYGEN SYSTEM

An oxygen system is designed to deliver a sufficient quantity of pure (99.9 percent) oxygen to one or more persons connected to it who are unable for physiological reasons to breathe enough oxygen from the surrounding rarefied atmosphere. The system must include a cylinder containing a compressed volume of gas and a system of tubing to convey it to a regulator which is designed to reduce the pressure and meter it to the user. An efficient oxygen regulator must mix pure oxygen with the prevailing air in sufficient quantities and proportions in order not to waste the supply and to deliver it on demand as the user inhales. The oxygen supply is connected to the user through a mask and a flexible extension tube connected to the output side of the regulator. Latest pressure type oxygen regulators will not only dilute the oxygen, delivering it on demand, but will also automatically increase the pressure of the output flow. This increase in output pressure improves the limits of its efficiency for use at greater altitudes. Airtightness is essential to the limits under which any system can be successfully utilized. The dilution of oxygen must take place in the regulator, and not through a careless fitting of a leaky mask or poor tube connection. Since man is limited to the amount of additional pressure that can be forced into his lungs, engineers have designed the pressurized cabin or cockpit, the pressurized suit, and pressure regulator. These advancements have increased the service ceiling of oxygen systems approximately twofold; however, there remains the need for further improvement before greater altitudes can be obtained.

A liquid oxygen system operates identically to the all-gaseous system from the regulators to the crewmembers. Liquid systems will be discussed in chapter 5.

QUIZ

1. A sample of dry air contains
    a. 78 percent oxygen
    b. 21 percent oxygen
    c. 1 percent carbon dioxide
    d. 78 percent partial pressure
2. The atmosphere is held to the earth's surface by
    a. 14.7 p. s. i. pressure
    b. gravity
    c. friction
    d. a gaseous outer cover
3. The atmospheric pressure at sea level is
    a. 14.7 p. s. i.
    b. 7.35 p. s. i.
    c. 3 p. s. i.
    d. none of the above

4. Credit for the discovery of oxygen is given to
   a. Joseph Priestly
   b. Karl Scheele
   c. Lavoisier
   d. Albert Einstein
5. An oxygen partial pressure of 3 p. s. i. is necessary to sustain life because that is the amount of pressure necessary to
   a. force the oxygen into the blood stream
   b. carry off excess carbon dioxide
   c. make the oxygen regulator function correctly
   d. lengthen the duration of an oxygen cylinder
6. We cannot go above 35,000 feet without the assistance of pressure breathing or cabin pressurization because
   a. of the low oxygen partial pressure above 35,000 feet
   b. of less oxygen
   c. the air is thinner
   d. duration is shorter
7. A complete lack of oxygen is called
   a. aero embolism
   b. anoxia
   c. hypoxia
   d. bends
8. Compressed oxygen should never be mixed with
   a. hydrocarbons
   b. grease
   c. oil
   d. all of the above
9. All gaseous aviator's breathing oxygen is derived from liquid oxygen by a process known as
   a. fractional dilution
   b. frictional distillation
   c. fractional distillation
   d. frictional dilution
10. The maximum allowable water vapor content of aviator's breathing oxygen is
    a. 0.2 milligram per liter
    b. 2 milligrams per liter
    c. 0.02 milligram per liter
    d. 20 milligrams per liter
11. The greatest danger of water vapor in an oxygen system is
    a. water particles freezing in the working parts of the regulator
    b. the pilot catching a cold
    c. water freezing in the cylinder
    d. water freezing in the oxygen mask

12. An oxygen cylinder should never be exhausted below
    a. 14.7 p. s. i.
    b. 15 p. s. i.
    c. 500 p. s. i.
    d. 300 p. s. i.
13. The only two oxygen cylinders approved for use in a permanent high pressure system are the
    a. 514 and 295 cubic inch
    b. D–2 and J–1
    c. 92 and 96 cubic inch
    d. 205 and 22 cubic inch
14. On a high pressure oxygen system, operational empty is considered as being
    a. 300 p. s. i.
    b. 15 p. s. i.
    c. 100 p. s. i.
    d. 500 p. s. i.
15. The greatest danger resulting from hypoxia is the fact that
    a. it is difficult to recognize
    b. it can develop into anoxia
    c. the brain suffers from lack of oxygen which results in the remainder of the organs and senses not functioning properly
    d. all of the above result
16. The only way the atmosphere does not change while ascending to altitude is in
    a. atmospheric pressure
    b. composition
    c. temperature
    d. relative humidity
17. A means of diluting oxygen with air is provided on oxygen regulators for the purpose of
    a. prolonging the supply of oxygen
    b. adding partial pressure
    c. diluting 100 percent oxygen as it might be harmful if breathed undiluted
    d. decreasing partial pressure
18. A water vapor content is specified for grade A oxygen but not for grade
    a. C
    b. E
    c. B
    d. D

19. Type II oxygen is
    a. aviator's breathing oxygen
    b. liquid oxygen
    c. welding oxygen
    d. hospital oxygen

20. Oxygen is purchased by volume in units of
    a. pounds per square inch
    b. cubic feet
    c. cubic inches
    d. cubic yards

21. Oxygen cylinder duration is computed from an operating pressure of
    a. 2,000 p. s. i.
    b. 1,800 p. s. i.
    c. 1,200 p. s. i.
    d. 1,500 p. s. i.

22. The atmosphere is composed of
    a. 21 percent oxygen
    b. 78 percent oxygen
    c. 14.7 percent oxygen
    d. 99.5 percent oxygen

23. For every thousand feet of altitude the temperature drops
    a. 3½° C.
    b. 3½° F.
    c. 3° F.
    d. 14.7° C.

24. The oxygen partial pressure at sea level is approximately
    a. 3 p. s. i.
    b. 20 percent of the atmospheric pressure
    c. ⅕ of the atmospheric pressure
    d. all of the above

25. Oxygen partial pressure loss, above 35,000 feet, is provided for by a
    a. continuous flow oxygen regulator
    b. demand type oxygen regulator
    c. pressure demand type oxygen regulator
    d. diluter-demand type oxygen regulator

CHAPTER 2

OXYGEN BREATHING REGULATORS

DILUTER-DEMAND OXYGEN REGULATORS

The success or failure of high altitude flight depends primarily on the functioning of an oxygen breathing regulator. The oxygen regulator, acting as a metering device, is the very heart of the oxygen system. To perform successfully in a permanent system a regulator must deliver the life-supporting gas demanded in proper quantities throughout its entire range of operation. A modern pressure diluter-demand oxygen regulator, a complex instrument, is designed to deliver oxygen while mixing it with varying quantities of air, depending on changes in atmospheric pressure. It is also capable of delivering undiluted oxygen, automatically increasing delivery pressure when the aircraft reaches a prescribed altitude. Other more simply constructed regulators may be installed in noncombatant or large multiengine aircraft oxygen systems. However, a lot is lacking in the versatility of performance required of a complex instrument installed in combatant type aircraft. The mission of the aircraft determines the suitability of its equipment.

AN6004–1 Diluter-Demand Regulators

Diluter-demand oxygen regulators used by the Navy conform with an Army-Navy Aeronautical Standard drawing designated as AN6004–1. The drawing shows the basic external characteristics, such as the location of controls and connections. At present, the only AN6004–1 regulators used by the Navy are manufactured and designed by the Eclipse-Pioneer Division of the Bendix Aviation Corporation.

An example of a typical Pioneer diluter-demand regulator type identification reads as follows: 2858–A1. This regulator among others contains the characteristics specified in drawing AN6004–1 and is interchangeable with other types or series as long as the range of input pressure is correct.

OPERATION.—The 2858 series diluter-demand regulator delivers an adequate breathing volume, the composition of which is dependent upon the flight altitude and the setting of the regulator air valve. Figure 2–1 illustrates the basic principles of operation of the Pioneer diluter-demand oxygen regulator.

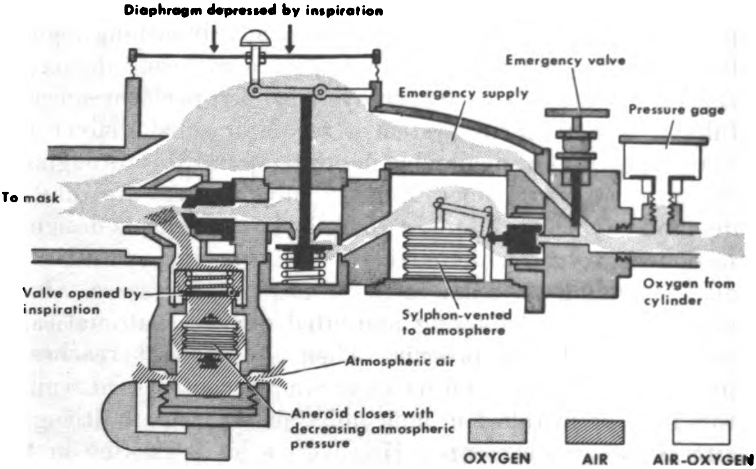
Diaphragm depressed by inspiration
Emergency valve
Emergency supply
Pressure gage
To mask
Valve opened by inspiration
Oxygen from cylinder
Sylphon-vented to atmosphere
Atmospheric air
Aneroid closes with decreasing atmospheric pressure
OXYGEN
AIR
AIR-OXYGEN

Figure 2–1.—Schematic flow diagram (Pioneer oxygen regulator).

With the 2858 series oxygen regulator's air valve set to the NORMAL OXYGEN position (fig. 2–2), air is drawn into the breathing system and is automatically mixed with oxygen from the supply cylinder. This gives the total needed oxygen required up to approximately 30,000 feet; beyond 30,000 feet 100-percent oxygen is delivered.

With the air valve set to the 100-PERCENT OXYGEN position (fig. 2–3), 100-percent oxygen is delivered at all altitudes.

When the air valve is set to NORMAL OXYGEN, a relatively small suction (one inch of water suction) is sufficient to deliver a flow of 150 liters of diluted oxygen per minute. This as-

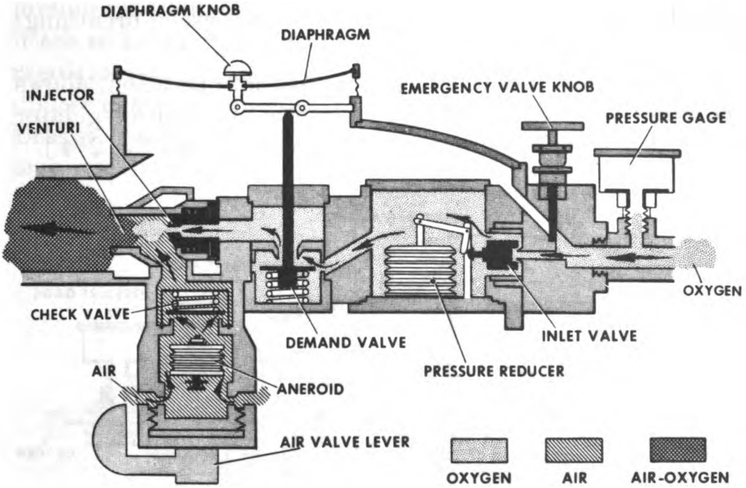

Figure 2–2.—Air valve—*Normal Oxygen.*

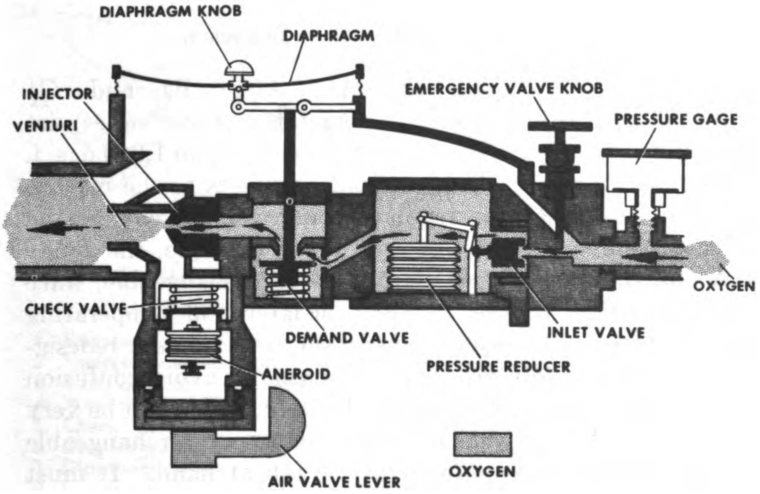

Figure 2–3.—Air valve—*100-percent oxygen.*

sures the user an adequate oxygen flow and ease of breathing. (See fig. 2–2).

An emergency valve, opened by manual operation, allows a continuous stream of oxygen to bypass the entire regulator mechanism and flow directly to the mask. (See fig. 2–4.)

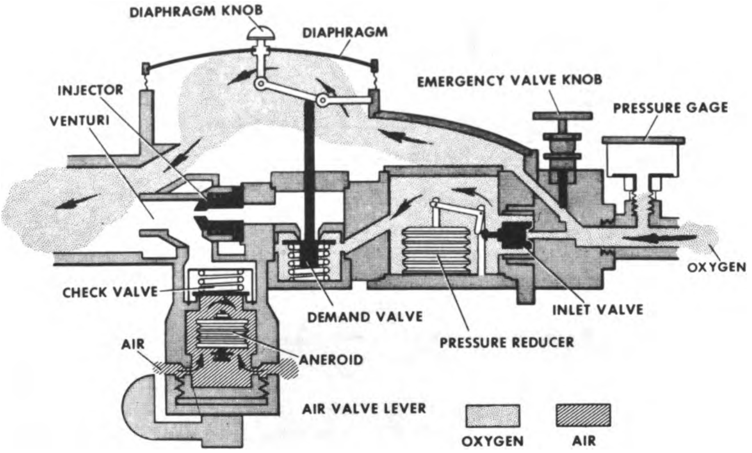

Figure 2–4.—Emergency valve—*Emergency.*

Construction.—Types 2858–A1, –A1A, –B1, and –C1 of the AN6004–1 series (diluter-demand regulator series) are constructed to operate on an input pressure up to 1,800 p. s. i. (60 to 1,800 p. s. i.). Internal improvements to the mechanisms of the 2858 type regulator progressively change the suffix or modification designation. For example, the 2858–A1A and the 2858–B1 regulators are interchangeable, since no major change has been made to the later model's operating characteristics. A major change usually requires a redesignation of an entirely new type regulator to avoid confusion and the contingency of misusing the item, which can be very dangerous. Always make certain that an interchangeable item is completely adaptable to the job at hand. It must perform equally as well as the former, and under identical conditions. One cannot install a low-pressure regulator, designed to operate on a maximum inlet pressure of 500 p. s. i., in a high-pressure system where the maximum inlet pressure is 1,800 p. s. i. However, no damage would be done if the situation were reversed, and a high-pressure operating regulator were installed in a low-pressure system. All diluter-demand regulators of the AN6004–1 series and the Eclipse Pioneer 2860 and 2870 series are designed to operate on an approximate range of pressure between 60 and 1,800 p. s. i.

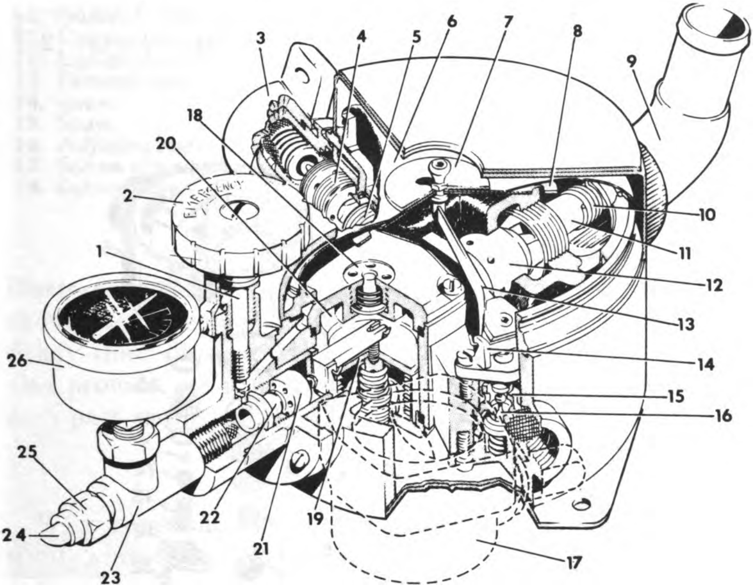

Figure 2–5.—Three-quarter cutaway view—diluter-demand oxygen regulator—type AN6004–1 (Pioneer type 2858–A1).

1. Emergency valve shaft assembly.
2. Emergency valve knob.
3. Body and cover assembly.
4. Aneroid assembly.
5. Check valve.
6. Diaphragm assembly.
7. Diaphragm washer.
8. Lower disk.
9. Elbow assembly.
10. Lock spring.
11. Venturi.
12. Injector assembly.
13. Diaphragm lever assembly.
14. Bracket and bushing assembly.
15. Demand valve.
16. Demand valve stem.
17. Oxygen flow indicator.
18. Relief valve assembly.
19. Pressure reducer assembly.
20. Bellows dampener.
21. Inlet valve.
22. Oxygen inlet orifice.
23. Tee.
24. Union cone.
25. Union nut.
26. Gage.

The 2858–A1 diluter-demand oxygen regulator is illustrated in a three-quarter cutaway view in figure 2–5.

Eclipse Pioneer oxygen regulators, 2858–A1 and 2858–C1, are used in older model combatant aircraft and in many up-to-date noncombatant aircraft. A check of the latest section of the *ASO Catalog*, listing oxygen breathing equipment, will indicate which type regulator a particular model aircraft is using. Also indicated, and very important, are the items which are interchangeable.

Figure 2–6 illustrates an exploded view (type AN6004–1) of the bottom half of the main assembly. Figure 2–7

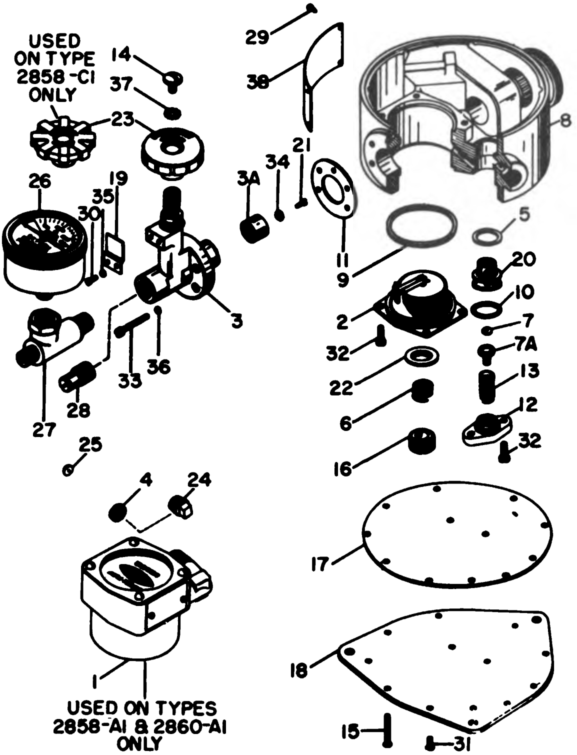

Figure 2–6.—Exploded view of bottom half of the main assembly (Pioneer types 2857–A1, 2858–A1, –A1A, –B1, and –C1).

Nomenclature for figure 2–6

1. Oxygen flow indicator assembly.
2. Pressure reducer assembly.
3. Emergency valve assembly.
3A. Inlet valve and insert assembly.
4. Screen.
5. Gasket.
6. Bellows spring.
7. Demand valve seat.
7A. Demand valve seat holder.
8. Case and locating pin assembly
9. Gasket.
10. Gasket.
11. Oxygen inlet gasket.
12. Low-pressure valve cap.
13. Demand valve spring.
14. Screw.
15. Screw.
16. Adjusting screw.
17. Bottom plate gasket.
18. Bottom plate.
19. Emergency valve stop.
20. Demand valve.
21. Screw.
22. Spacer.
23. Emergency valve knob.
24. Plug.
25. Blinker orifice.
26. Oxygen gage.
27. Tee.
28. Shipping plug.
29. Screw.
30. Screw.
31. Screw.
32. Screw.
33. Screw.
34. Nut.
35. Lockwasher.
36. Lockwasher.
37. Shakeproof lockwasher.
38. Nameplate.

illustrates an exploded view of the same type regulator, but shows the parts located in the top half of the main assembly. Study these illustrations for nomenclature purposes. They also provide a better understanding of the relationship of each part in the assembly.

Type A–14 Aero Regulator

WHY PRESSURE-DEMAND EQUIPMENT IS NEEDED AT VERY HIGH ALTITUDES.—When using the conventional diluter-demand oxygen equipment previously described, the pressure in the lungs is at all times very nearly the same as the pressure of the atmosphere outside the body. Although this pressure decreases constantly when ascending, the demand equipment will nevertheless provide a concentration of oxygen entirely adequate for any reasonable activity up to an altitude of about 35,000 feet. Between 35,000 and 40,000 feet, because of the declining pressure of the oxygen in the lungs, there will be some reduction in the oxygen load of the blood. However, if the mask fit is free from leakage, there is no danger of hypoxia. Above 40,000 feet however, as the oxygen load of the blood continues to decline with the decreasing pressure,

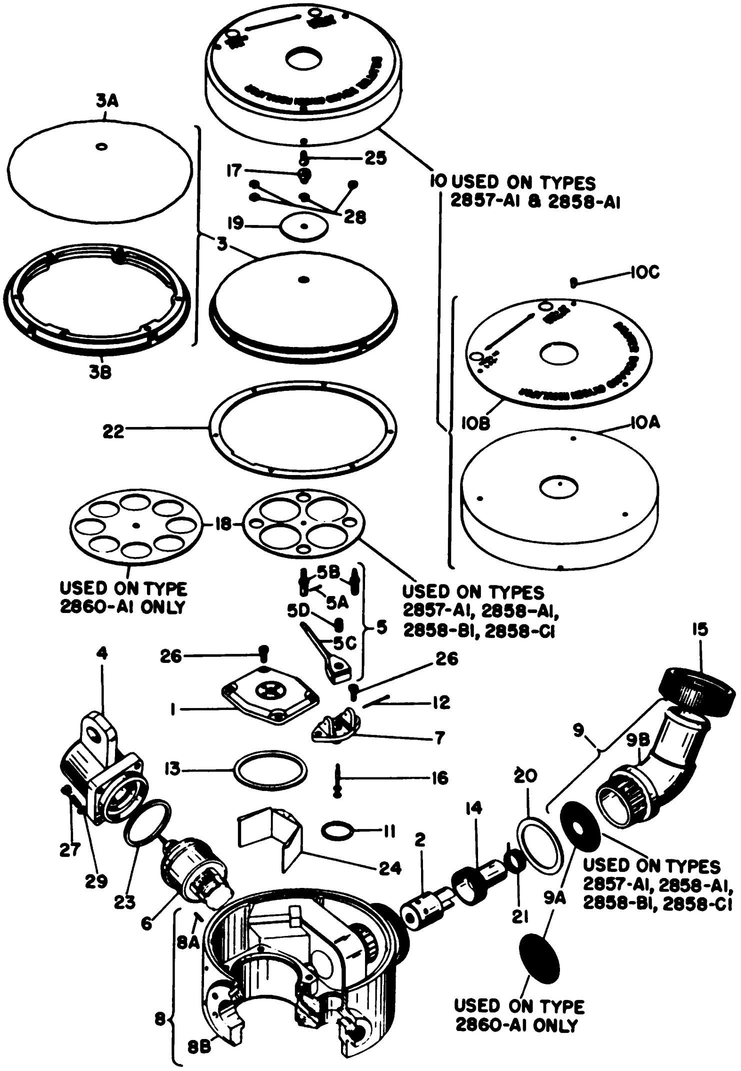
3A
25
17
10 USED ON TYPES 2857-AI & 2858-AI
28
19
3
10C
3B
10B
10A
22
18
USED ON TYPE 2860-AI ONLY
5B
5A
USED ON TYPES 2857-AI, 2858-AI, 2858-BI, 2858-CI
5D
5
5C
15
4
26
26
1
12
7
9
9B
13
16
20
14
11
2
27
24
29
23
USED ON TYPES 2857-AI, 2858-AI, 2858-BI, 2858-CI
9A
21
6
8A
USED ON TYPE 2860-AI ONLY
8
8B

Figure 2-7.—Exploded view of top half of the main assembly (Pioneer types 2857–A1, 2858–A1, –A1A, –B1, and –C1).

Nomenclature for figure 2–7

1. Relief valve assembly.
2. Injector assembly.
3. Diaphragm assembly.
3A. Diaphragm ring.
3B. Diaphragm.
4. Body and cover assembly.
5. Diaphragm lever assembly.
5A. Pin.
5B. Diaphragm link.
5C. Diaphragm lever.
5D. Setscrew.
6. Check valve and aneroid assembly.
7. Bracket and bushing assembly.
8. Case and locating pin assembly.
8A. Pin.
8B. Case.
9. Elbow assembly.
9A. Elbow screen.
9B. Elbow.
10. Cover assembly.
10A. Cover.
10B. Dial.
10C. Rivet.
11. Gasket.
12. Pin.
13. Gasket.
14. Venturi.
15. Elbow nut.
16. Demand valve stem.
17. Diaphragm knob.
18. Lower disk.
19. Diaphragm washer.
20. Gasket.
21. Lock spring.
22. Diaphragm ring gasket.
23. Gasket.
24. Bellows dampener.
25. Screw.
26. Screw.
27. Screw.
28. Nut.
29. Lockwasher.

hypoxia becomes more and more severe. Forty thousand feet, therefore, is considered to be the absolute ceiling for short periods while using straight diluter-demand equipment. This is provided by the 2858 Pioneer regulator or its equivalent.

There are two ways to maintain an adequate oxygen intake even above 40,000 feet. One is by means of a pressurized cabin or a pressurized suit, which will provide adequate pressure both inside and outside the body. The other is by means of pressure-demand equipment (pressure regulator and pressure mask), which supplies oxygen to the lungs at a pressure slightly higher than that outside the body. Because the body can stand only a limited excess of internal pressure, the effective range of pressure-demand equipment is also limited. Flights to altitudes exceeding 40,000 feet above sea level should not be undertaken in aircraft equipped with regulators employing a manual safety press as their only means of attaining the additional safety pressure needed. Operational limits of equipment change from time to time corresponding with new methods and developments; therefore, it is necessary to consult the latest applicable technical publications, such as *Bureau of Aeronautics Bulletins* and *Handbooks of Operating Instructions*, before instituting any set practice.

The regulator and the mask are the only features of the pressure diluter-demand oxygen apparatus which differ from the conventional diluter-demand equipment. Even these items work in the same way as the corresponding parts of demand equipment, and are used in the same way until the positive pressure mechanism comes into operation either by manual positioning by the user or automatically by aneroid control.

DESCRIPTION.—The A–14 regulator (fig. 2–8) is similar to AN6004–1 (diluter-demand regulator), except that the diaphragm can be depressed by an adjustable lever. The lever is adjusted by means of a pressure control knob which turns a dial on the face of the regulator. With the pressure control knob set to NORMAL, the regulator works in exactly the same way as the Aero type A–12A or AN6004–1. Turning the knob clockwise results in a steady flow of oxygen from the demand valve. This flow continues until sufficient pressure is built up inside the mask and regulator to oppose the tension of the lever against the diaphragm, and thus close the demand valve. The pressures which are produced in the oxygen mask and in the lungs at various settings of the regulator dial are listed in table 2–1.

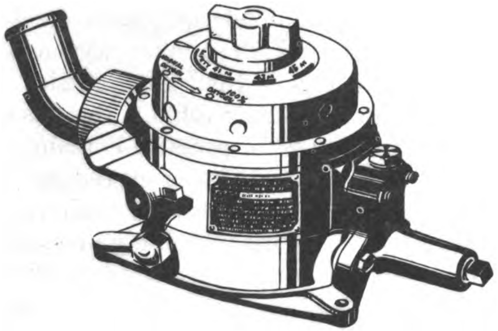

Figure 2–8.—Type A–14 pressure breathing diluter-demand oxygen regulator.

Table 2-1.—Pressure factors

Dial setting	Approximate pressure delivered
NORMAL	SAME AS AMBIENT PRESSURE.
SAFETY	1.75 in. H_2O.
41M	4.0 in. H_2O.
43M	6.0 in. H_2O.
45M	8.0 in. H_2O.
Above 45M	12.0 in. H_2O.

NOTE: M is the Roman numeral for one thousand. H_2O is the chemical symbol for water. Low pressures are usually read on a scale in inches of water; because of the specific gravity (weight) of water, it will readily indicate small changes in pressure.

OPERATION.—When an A-14 regulator is used in nonpressurized aircraft, the dial is set with reference to flight

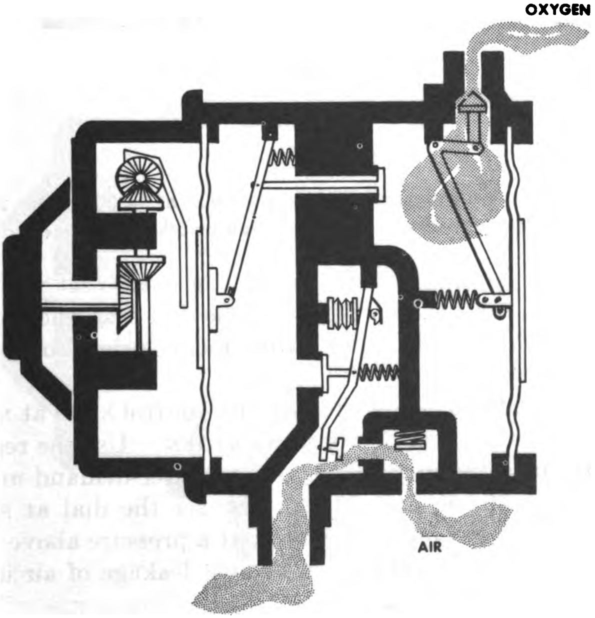

Figure 2-9.—A-14 regulator during inhalation at sea level. Oxygen valve is closed; air valve is open; and you breathe air only.

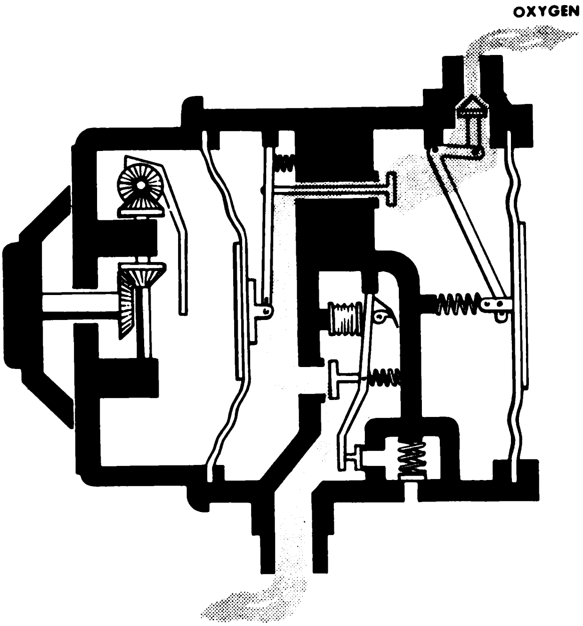

Figure 2–10.—A–14 regulator during inhalation at 34,000 feet. Air valve is closed; oxygen valve is open; and you breathe 100-percent oxygen.

altitudes. In pressurized aircraft, the dial is set with reference to cabin altitude. Advance the dial first, then increase altitude. Make the dial adjustment prior to reaching altitude.

Up to 30,000 feet, set the pressure control knob at NORMAL and the diluter lever at NORMAL OXYGEN. Use the regulator exactly the same way as any other diluter-demand unit.

Between 30,000 and 40,000 feet, set the dial at SAFETY. This supplies oxygen to the mask at a pressure above that of the outside air for protection against leakage of air into the mask. (See table 2–2.)

Type A–14 regulators have no special emergency valve. The pressure control knob can be used, however, to obtain an increased output pressure. This is useful in the event of

Table 2-2.—Dial settings—40,000 feet and above

Cabin altitude	Dial setting
40,000 feet	41M.
41,000 feet	41M.
42,000 feet	43M.
43,000 feet	43M.
44,000 feet	45M.
45,000 feet	45M.
Above 45,000 feet	For emergency use only.

The A-14 regulator was designed for altitudes above 45,000 feet. However, presently published operational limits restrict service type aircraft from using any oxygen equipment above 45,000 feet. These restrictions review the various model regulators and limit their use in accordance with their design and altitude potential.

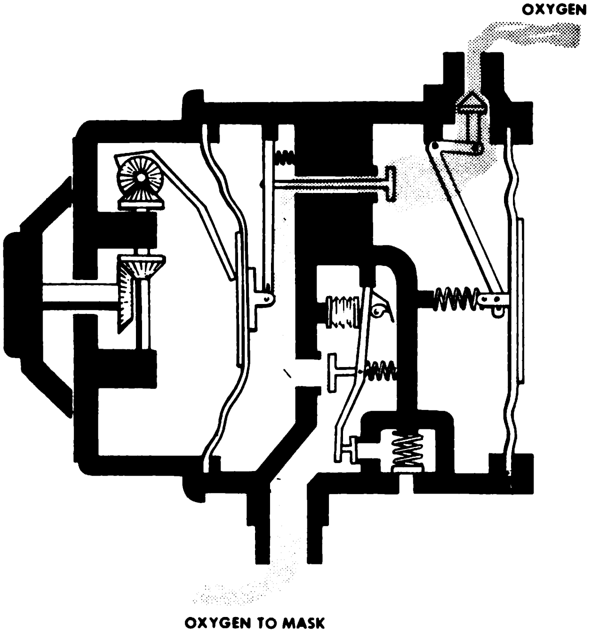

Figure 2-11.—A-14 regulator during inhalation with pressure breathing. Spring presses down on diaphragm, opening demand valve and forcing oxygen into mask under pressure.

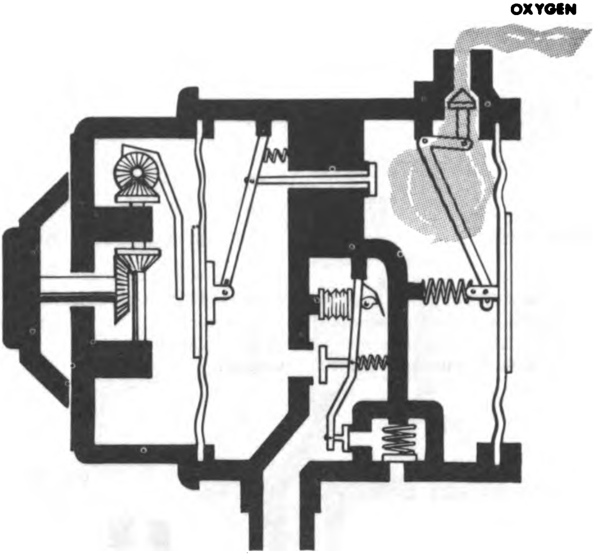

Figure 2–12.—A–14 regulator during exhalation with pressure breathing. As you exhale, the pressure raises momentarily in the mask above the oxygen supply pressure, forcing the diaphragm up against the spring tension. The demand valve closes and no oxygen flows.

serious and uncorrectable mask leakage, but it should be done with caution under other circumstances. The use of this knob will result in greatly increased oxygen consumption, particularly at altitudes of 30,000 feet and below. Figures 2–9 through 2–12 illustrate the operation of the A–14 regulator.

Automatic Positive Pressure and Composite Diluter-Demand Oxygen Regulators

DIFFERENCES BETWEEN TYPES.—All regulators types 2862–A1, –A2, –B1, and –C1 have identical front-panel controls, and basic regulator components mounted in the case. One would have to study the internal exploded views to determine the minor differences in physical appearance. A gasket removed here, one added there, a stronger spring, the addition of a pin—all these slight physical changes which improve the design's operation will also change its suffix designation. A working knowledge of such details is not necessary unless one is authorized to overhaul and repair this equipment. All 2862 types are equipped with automatic pressure-breathing backs. Types 2863–A1, –A2, –B1, and –C1 do not incorporate pressure-breathing backs, and therefore do not have as great an altitude range as the 2862 regulator series. Also, the external appearance of the cover assemblies differ (between the 2862 and 2863 models), the inlet valve assembly is slightly different, and the flow indicator window is elliptically shaped instead of being rectangular. (See fig. 2–13.) Slight internal modifications within the model itself (2863) change its suffix designations, corresponding with its improvements.

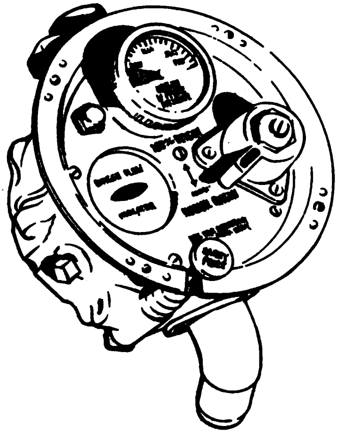

Figure 2–13.—Three-quarter view—composite diluter-demand oxygen regulator, Eclipse Pioneer type 2863–A1.

The 2867–A1B differs from the 2862 models especially in external appearance although the regulators employ the automatic pressure-breathing back assemblies. The 2867–A1B is fitted with a different cover plate, the inlet valve incorporates a shutoff lever which permits shutting off the oxygen supply at the regulator, and its safety-press shaft is operated differently. (See fig. 2–14.) Type 2872–A1B is the same in appearance as type 2867–A1B except that it is not equipped with an automatic breathing back. Type 2873–A1 is an automatic positive pressure diluter-demand oxygen regulator, and is similar to the 2867–A1B except that it is not equipped with a manual shutoff valve incorporated in the regulator inlet assembly. Type 2874–A1 differs from the 2873–A1 regulator since it is not equipped with an automatic pressure-breathing back. Figures 2–13 and 2–14 illustrate the external appearances of the regulators.

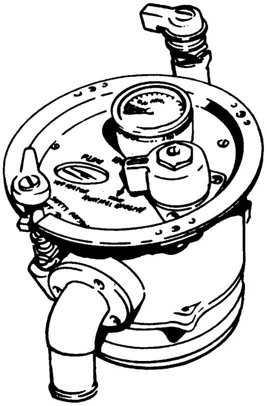

Figure 2–14.—Three-quarter view—automatic positive pressure diluter-demand oxygen regulator, Eclipse Pioneer type 2867–A1B.

Description.—Only pressure-breathing masks, such as type A–13, can be used with these regulators. With a tight mask, and the regulator supplying 100-percent oxygen, the maximum ceiling for types 2862–A1, –A2, and –B1, 2864–A1, and –A2, 2867–A1B, and 2873–A1 is approximately 43,000 feet; while the maximum ceiling for types 2863–A1, –A2, –B1, and -C1, 2872–A1B, and 2874–A1 is approximately 40,000 feet.

Regulator models 2863, 2872, and 2874 are designed for use in airplanes having a service ceiling BELOW 40,000 feet. Other models, such as the 2858, A–12A, or ARO 17600–A regulators, were designed for the same purpose. All these regulators are standard acceptable items to be retained in aircraft until replaced in the normal service manner.

Models 2862, 2864, 2867, and 2873 are designed for use in aircraft having service ceilings ABOVE 35,000 feet. These regulators operate on the identical diluter-demand principle previously described, but incorporate an additional feature which provides for delivery of 100-percent oxygen under positive pressure at high altitudes. This positive pressure varies from 2 inches of water at 35,000 feet to 10 and 12 inches of water at 43,000 feet. This positive pressure delivery of oxygen to the mask serves a dual purpose. First, it eliminates the possibility of inward leakage during inhalation and, therefore, dilution of oxygen. Second, this boost in pressure at the mask raises the maximum safe breathing altitude approximately 10 percent without exceeding the physical limitation imposed by exhalation effort against ever increasing pressures in the mask.

During conditions of abnormal or inadequate supply of oxygen regulators, substitution of different models within a group capable of the same range may be made. Consult the Bureau of Aeronautics *Aviation Clothing and Survival Equipment Bulletins* and other applicable technical publications for information authorizing such substitutions.

The oxygen regulator is connected between a cylinder in the aircraft and the mask of the user. Oxygen delivery pressure ranging from 1,800 p. s. i. (high-pressure system) down to a pressure of 50 p. s. i. can be admitted to a regulator inlet. This is the range through which a regulator having a working pressure of 40 to 60 p. s. i. can be expected to function properly. Consequently, any pressure lower than 50 p. s. i. will not operate a regulator (calibrated to 40–60 p. s. i.) efficiently. Because this factor adversely affects the operation of the regulator, the operational empty value is established as being 300 p. s. i. This figure is well above the emergency operational pressure of 50 p. s. i., and therefore, permits a safe descent to lower altitudes. When a pressure reducer is installed in a high-pressure system (making it a reduced high-pressure system), it will deliver a calibrated pressure ranging between 40 and 60 p. s. i. A pressure gage, mounted on a regulator supplied through a pressure reducer, will not indicate readings in excess of its calibrated delivery pressure. For a reading of the pressure remaining in the system, a pressure gage must be connected between the source of pressure and the inlet of the pressure reducer.

More information is given on this subject under pressure reducers and in another chapter concerning oxygen systems. To continue with these generalizations outlining the part of a regulator in relation to its system, air is admitted to the regulator through the air valve on the regulator panel. Three gas channels within the regulator case converge at the outlet assembly for conduction of oxygen or a mixture of oxygen and air to the mask.

Under normal conditions of operation, oxygen flows through the first channel. It passes through an inlet valve in the inlet assembly to a pressure reducer assembly that reduces the oxygen pressure to a value between 40 and 60 pounds. This feature makes operation of the regulator substantially unaffected by changes of oxygen cylinder pressure.

Suction created in the regulator by inhalation at the mask moves a diaphragm. Motion of the diaphragm operates a mechanical linkage to a demand valve causing the demand valve to pass a quantity of oxygen proportional to the demand. Flow of oxygen through the demand valve is indicated by oscillation of a plate under the oxygen flow indicator dial on the regulator panel. The oxygen channel is completed through an injector assembly and mixing tube to the outlet of the regulator.

Manual depression of a SAFETY-PRESS knob on the regulator panel of all types of regulators, except types 2867–A1B, 2872–A1B, 2873–A1, and 2874–A1, delivers oxygen at the outlet at 1¾±¼ inches of water pressure. The outlet pressure value is expressed in inches of water pressure instead of pounds per square inch, since the testing apparatus used to measure this very low flow employs a water filled manometer calibrated to indicate such readings in inches of water pressure. One inch of water is equivalent to 0.036 p. s. i., so rather than use decimals or fractions to express very low pressures, it is simpler to indicate them in inches of water pressure. (There is no gage available to read 0.036 p. s. i.) The SAFETY PRESSURE builds up inside the mask and, therefore, eliminates inward leakage at that location. The same function is accomplished on types 2867–A1B, 2872–A1B, 2873–A1, and 2874–A1 regulators by turning the SAFETY PRESSURE handle on the regulator panel clockwise to the ON position.

In the second channel, air enters the regulator through an air valve mounted on the regulator foreplate when the valve knob is positioned to NORMAL OXYGEN. The quantity of air passed is controlled by the operation of an ANEROID and CHECK VALVE assembly. As altitude is increased, the aneroid progressively closes off the air channel until, between

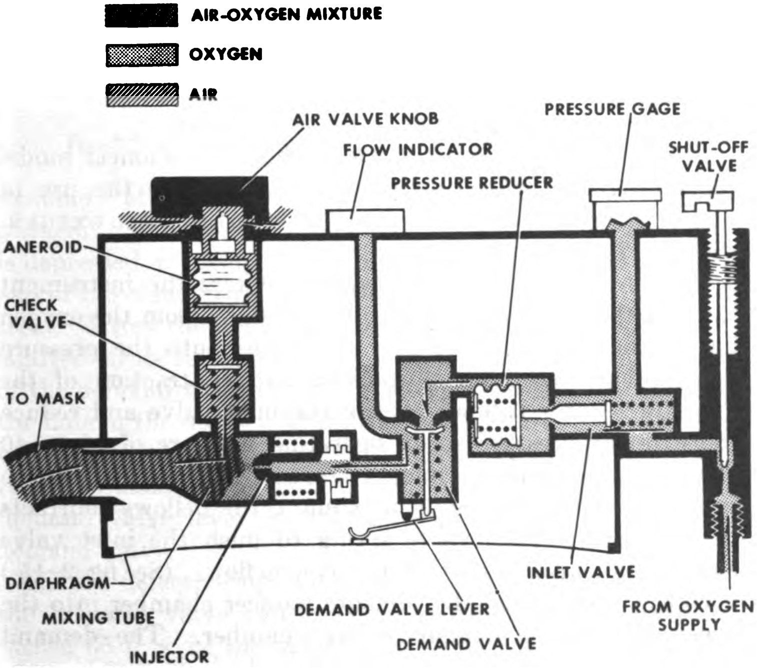

Figure 2–15.—Schematic operation diagram, normal oxygen—2867–A1B and 2872–A1B regulators.

a 28,000- and 32,000-foot altitude, the air channel is completely closed. The air channel is also controlled by a spring-loaded check valve that opens the channel only in the event of negative pressure within the regulator. The air path is completed at the mixing tube where the quantity of air is mixed with oxygen and passed into the outlet of the regulator.

The emergency valve has been removed from all pressure type regulators for reasons to be explained later.

OPERATION.—In general, operation of the regulator is controlled by the setting of its front panel controls. The sequence of events within the regulator under different conditions will be described and illustrated in the paragraphs to follow. Figures 2–15 through 2–17 apply equally well to all models of Pioneer regulators with the exception that a shutoff valve is installed on models 2867 and 2872. Types 2867–A1B contains an oxygen supply shutoff valve not shown in these figures. Figure 2–15 is a schematic representation of the operation of the type 2867–A1B regulator, SHOWING THE OXYGEN-SUPPLY SHUTOFF VALVE.

For a NORMAL OXYGEN FLOW of the other Pioneer model regulators, and when flight conditions require the use of dilutor oxygen, the air valve must be set at NORMAL OXYGEN. (See fig. 2–16.)

Oxygen from the supply cylinder enters the instrument through the inlet valve assembly. It flows from the oxygen inlet orifice through the inlet valve and into the pressure reducer chamber. The expansion and contraction of the pressure reducer bellows control the inlet valve and reduce the cylinder pressure to an operating pressure of 60 to 40 pounds, depending on inlet pressure. When the pressure in the chamber reaches its maximum, the bellows contracts permitting the inlet valve spring to push the inlet valve against its seat and shut off the oxygen flow. (See fig. 2–15.)

Oxygen flows from the pressure reducer chamber into the lower half of the demand valve chamber. The demand valve is controlled by the diaphragm which, in turn, is controlled by the person using the regulator. The tip of the

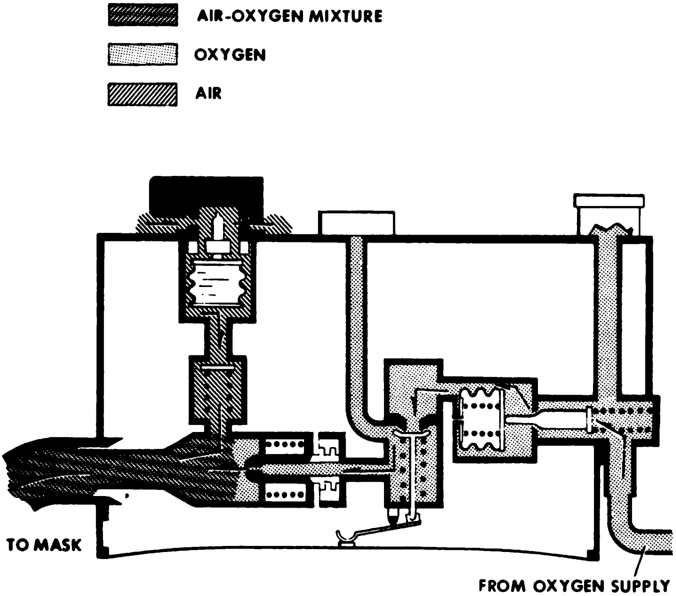

Figure 2–16.—Schematic operational diagram, *normal oxygen.*

demand valve lever presses against the center of the diaphragm. When the individual inhales, the diaphragm is depressed, pivoting the demand valve lever. The opposite end of the demand valve lever is pinned to the demand valve stem. When the diaphragm moves, the demand valve stem is lifted off its seat permitting oxygen to enter the upper half of the demand valve chamber. Oxygen then passes through the hole in the upper part of the demand valve chamber into the injector assembly. When the individual using the regulator exhales, the diaphragm is raised, thus pivoting the demand valve lever in the opposite direction to close the demand valve.

Should defective operation of any assembly upstream of the demand valve cause pressure inside the regulator to exceed 65 p. s. i., the demand valve acts as a safety valve. The pressure against the demand valve gasket and spring lifts the demand valve off its seat and the excessive pressure is dissipated at the mask.

When the air valve lever is turned counterclockwise, the air valve cover is raised above the air valve body. Air flows under the cover, through holes in the body, and continues down through the air valve screen into the aneroid and check valve assembly. At sea level the aneroid bellows is contracted permitting the air to pass through the base of the aneroid assembly. When the suction buildup is sufficient to overcome the pressure of the check valve disk against the aneroid and check valve assembly seat, the air continues into the air chamber. As higher altitudes are reached, decreasing atmospheric pressure allows the aneroid to expand, gradually forcing the throttling plate against the valve seat and eventually shutting off all airflow into the chamber. The air admitted to the air chamber flows into the mixing tube.

The check valve assembly, which closes when the person using the regulator exhales, prevents the escape of oxygen. It also prevents any flow of air until a definite suction is built up so that the air-oxygen mixture will not be too lean at small flows.

Oxygen from the demand valve flows into the injector assembly. As it leaves the injector nozzle, air from the air valve mixes with it. Upon inhalation, the mixture of air and oxygen is drawn through the mixer tube. The mixer tube delivers the air-oxygen mixture through the outlet to the oxygen mask.

The injector assembly is adapted to handle large quantities of oxygen under unusual conditions. The nozzle in the injector housing forms a valve with the injector seat. For high flows, the nozzle unseats itself and releases a greater quantity of oxygen through the holes in the lower portion of the injector housing.

Should there be need for pure oxygen or a 100-PERCENT OXYGEN FLOW before the aneroid automatically closes the air channel, it may be closed by positioning the air valve to 100-PERCENT OXYGEN. In this case, oxygen flow is the same as described above. (See fig. 2–17.)

MANUAL SAFETY PRESSURE on the regulators described in this section is accomplished by a manually operated safety

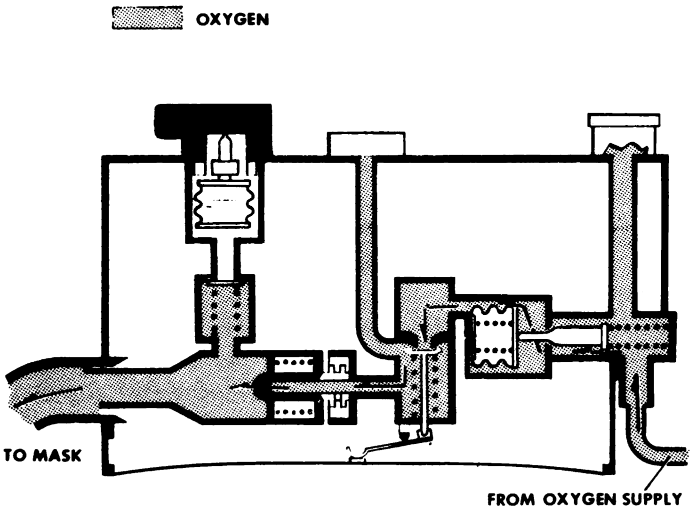

Figure 2-17.—Schematic operational diagram, 100-percent oxygen.

pressure mechanism incorporated in the regulator. When the SAFETY-PRESS knob of types 2862–A1, –A2, –B1, and –C1, 2863–A1, –A2, and –B1, and 2864–A1 is depressed, or the SAFETY PRESSURE arm of the other types of the related models is turned clockwise to the ON position, a spring-loaded lever depresses the diaphragm hub, which opens the demand valve. This permits the internal pressure of the regulator to increase slightly above the external pressure. Thus, when the individual using the oxygen regulator inhales, a negative pressure is set up in the mask. When the internal pressure in the regulator reaches 1¾ inches of water, the diaphragm is lifted sufficiently to close the demand valve. As long as the internal positive pressure of the regulator is adequate, the demand valve will remain closed even though the SAFETY-PRESS knob is depressed.

For AUTOMATIC POSITIVE PRESSURE BREATHING the automatic positive pressure mechanism in types 2862–A1, –A2, –B1, and –C1, 2864–A1, 2867–A1B, and 2873–A1 regulators incorporates an aneroid mechanism in the back of the regulator. As atmospheric pressure decreases with altitude, the

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aneroid expands and, through mechanical linkage to the diaphragm, progressively depresses the diaphragm allowing the internal regulator pressure to rise. (See fig. 2–18.)

INSTALLATION.—The installation of this equipment is made in accordance with the detailed specification for the

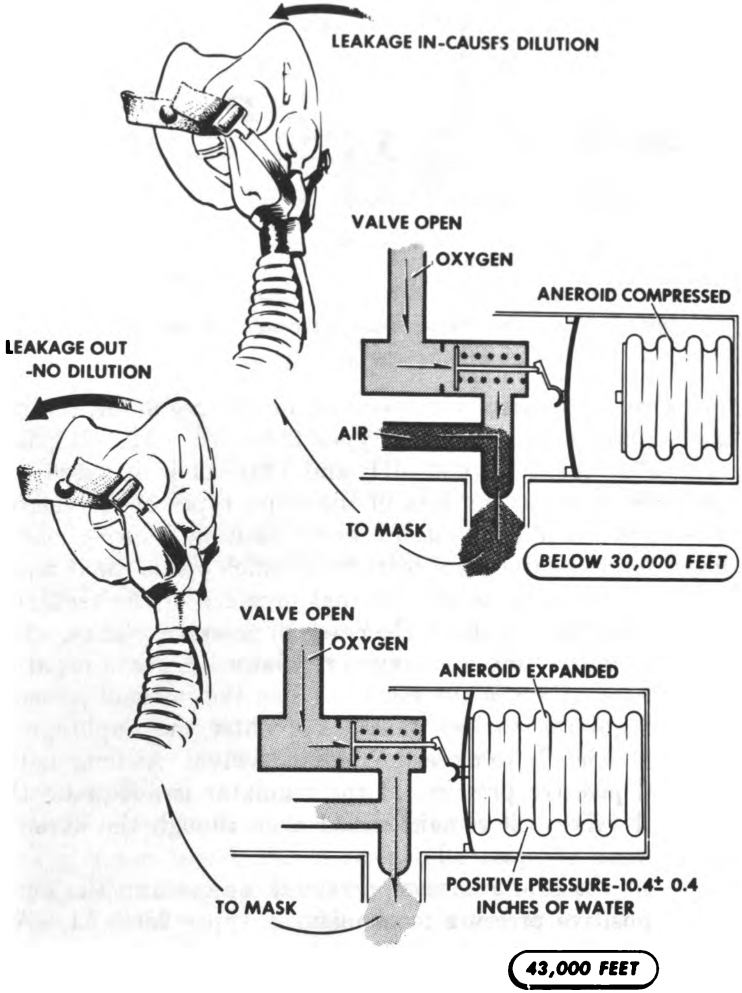


Figure 2–18.—Schematic operational diagram, automatic safety pressure.

particular aircraft in which it is installed. The regulator must not be mounted in a location exposed to oil drippings from hydraulic lines or other sources. Special care must be exercised to make certain that oil, grease, dirt, or other foreign matter is not allowed to collect in the tubing or any other part of the installation. Do not use oil or lead oxide or any substance containing these materials on the fittings of the oxygen regulator or other oxygen equipment.

A composite or positive pressure regulator is designed for back-of-panel mounting. It must be mounted within arm's reach of the person who is to use it, since the pilot or airman must be able to adjust the regulator controls in flight.

General instructions for connecting an oxygen regulator to a system follow:

1. Remove the shipping plug from the regulator inlet assembly. A $\frac{3}{16}$-inch outside diameter copper tubing complete with silver-soldered end fittings is provided with the airplane. Connect this tubing directly to the inlet assembly. Antiseize compound must be used on pipe threads. Do not tighten $\frac{3}{16}$-inch line connections to more than a 175 inch-pound torque.

2. In installations where a remote oxygen flow indicator is to be used, remove the $\frac{1}{8}$-inch pipe plug from the indicator outlet on the side of the regulator case. Connect the indicator to the regulator by $\frac{1}{8}$-inch outside diameter (O. D.) aluminum alloy tubing. This tubing has either a 0.035- or 0.032-inch wall thickness. The tubing must be no more than 10 feet in length.

3. Remove the wrapping from the appropriate breathing tube assembled with a quick-disconnect coupling. Attach the open end of the tubing to the regulator outlet using the hose clamp provided.

Pressure type oxygen face masks are constructed for use with manual and/or automatic SAFETY PRESSURE oxygen regulators. Distinctive construction features are evidenced by the installation of an inner lip and special type values. The encircling inner lip or flap is designed as an extra seal to hold pressures within, hence preventing leakage around the face mask. Specially designed inhalation and exhalation valves control its operation, and since ordinary oxygen masks are incapable of holding or controlling pressure, their use is confined to more moderate systems. Oxygen regulators equipped with emergency valves are potentially dangerous when they are teamed with pressure type face masks capable of confining pressures around the individual's nose and mouth. An appreciable sudden surge of pressure flowing uncontrolled into a mask designed to retain pressure can cause harmful effects to one's lungs. Also, a continuous flow of oxygen will not permit the user to open the mask's compensated exhalation valve. Consequently, emergency valves of the older pressure type regulators have been made inoperative by removing their actuating arms. Latest pressure type regulators are not equipped with emergency valves.

Figure 2–19 illustrates the installation of a composite oxygen regulator in an aircraft. In this case, the pilot's regulator is mounted in the left-hand control panel and is

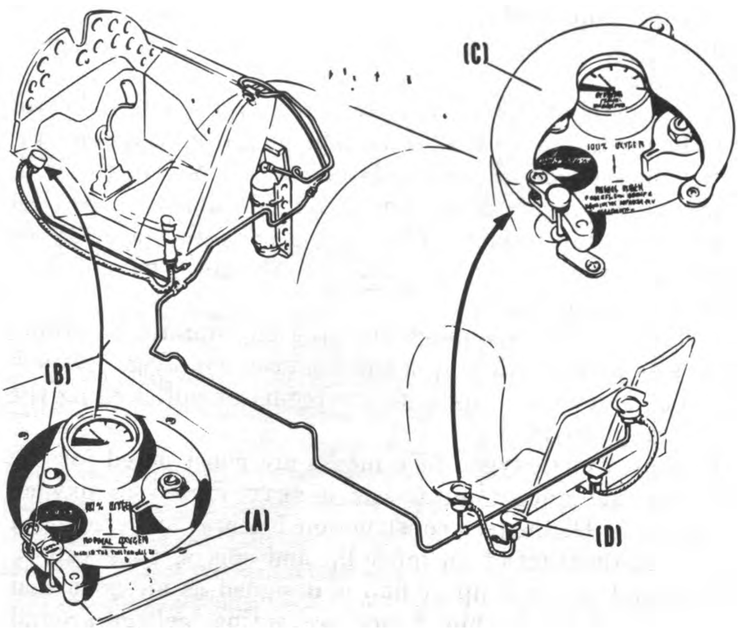


Figure 2–19.—Oxygen regulator installation.

fitted with a guard (A), and a spring-loaded arm (B), which act to prevent the inadvertent depression of the safety pressure button. On some airplanes, the guard to prevent inadvertent depression of the safety pressure button is incorporated on the faceplate of the regulator. Where necessary, other installations go a step further in protecting the oxygen regulator, and an additional metal guard (C), shaped to adequate proportions, is installed directly over the unit.

Regulator outlets are connected to the oxygen tube projections (D) of the personal receptacles. A series of aluminum tubing and/or flexible rubber, cloth-covered, wire-wound tubing is used to make the connections. Hose clamps secure the tubing connections and make the installation airtight.

Figure 2–19 is representative of a typical installation. However, there are so many different types of regulators and ways of installing them it would not be practical to present them all in a training course. *Aircraft Service Change Bulletins* and other publications resulting from new developments periodically modify the designs and principles originally built into an airplane and its equipment. In summing up this operation, here are a few details to be remembered:

1. Always ascertain the flight readiness of an airplane before starting to work on it.
2. Before installing a regulator, turn off the oxygen supply by disconnecting the supply cylinder or cylinders, or by closing a line or cylinder valve.
3. After disconnecting oxygen lines protect their exposed ends from the entrance of harmful elements.
4. Do not install an oxygen regulator, old or new, in a system unless it has previously been "bench checked," after having met all its operational requirements.
5. Once a regulator or regulators are installed, and the cylinder or cylinders have been connected wrenchtight, GROUNDCREW CHECK the entire system. Breathe through every regulator while using a mask connected to the personal receptacle or breathing extension tube "quick-disconnect."
6. It will be difficult to work on some installations because of their inaccessible locations. To reach them it will be

necessary to remove other items of the airplane's equipment, such as a seat, a panel, electrical connections, or mechanical linkages. This being the case, one must exercise extreme care in making certain that everything is returned to its original condition before completion of the operation.

7. Engage and fingertighten the first few threads of all connections before applying a wrench. Be certain that all connections are finally made wrenchtight. A cross-threaded connection, expecially in a high-pressure tubing system, will always leak.

8. While installing a regulator, do not stand on or brace yourself against connecting rods, linkages, or other items of the airplane's equipment that will become bent or damaged.

9. If you drop a screw, tool, or any other item of equipment while making an installation, it must be found before the airplane is ready for flight.

10. Enter all oxygen regulator changes in a logbook, listing all pertinent information, and notify the maintenance and operations departments that the airplane is UP for oxygen.

11. All oxygen regulators shall be removed from aircraft and bench tested to determine each regulator's suitability for continued service use whenever the regulator fails to meet the ground-crew or preflight tests; the regulator has been in service 90 DAYS; and when the regulator has been in service 120 AIRCRAFT HOURS subsequent to last shop test.

12. All regulators should be overhauled and/or repaired in accordance with existing directives whenever the regulator fails to meet requirements during a bench test; when it is installed in aircraft undergoing overhaul or modernization; when it fails to function satisfactorily; and when regulators have expired shelf lives.

13. All replacement regulators drawn from the supply system by operational commands should be bench checked prior to installation in aircraft.

MAINTENANCE.—Very little maintenance is necessary once an oxygen regulator has been installed in the system. Like other instruments, its operation is principally automatic; however, a faithful periodic inspection schedule must be carried out in order to make certain that it is performing properly. The very nature of the instrument, and the important part it plays in high altitude flight, demands a close and comprehensive inspection. This inspection must be performed by the Parachute Rigger prior to every high altitude flight. This inspection is called the GROUND-CREW CHECK. Pilots and airmen conduct their own preflight tests just prior to takeoff time. The preflight check is not as comprehensive as the ground-crew check which must be performed by experienced and qualified personnel who can guarantee the entire system as being in perfect mechanical condition. The importance of this phase cannot be overemphasized. At high altitudes the effects of the lack of oxygen often are not apparent to those using a defective system until it is too late to take corrective action.

In order to insure maximum flight safety during all normal and emergency conditions, flight personnel must use only approved oxygen masks (pressure masks with pressure regulators) which have been individually fitted by qualified personnel. A poorly fitted mask can nullify the value of any oxygen system or precautions taken to guarantee the system's operation.

System Leakage

Oxygen system leakage shall be determined by comparison of the oxygen cylinder pressure gage readings at the start and end of a 24-hour period. The system pressure shall not have decreased below the limits specified herein after the allowance for temperature changes has been made. Where the system pressure drop exceeds the specific allowable amount, excessive leakage is indicated, and the particular aircraft affected should not be flown above 10,000 feet until excessive leakage is eliminated. The allowable system pressure drop for a 24-hour period for high-pressure oxygen systems using ONE of the following size oxygen cylinders with one oxygen regulator is:

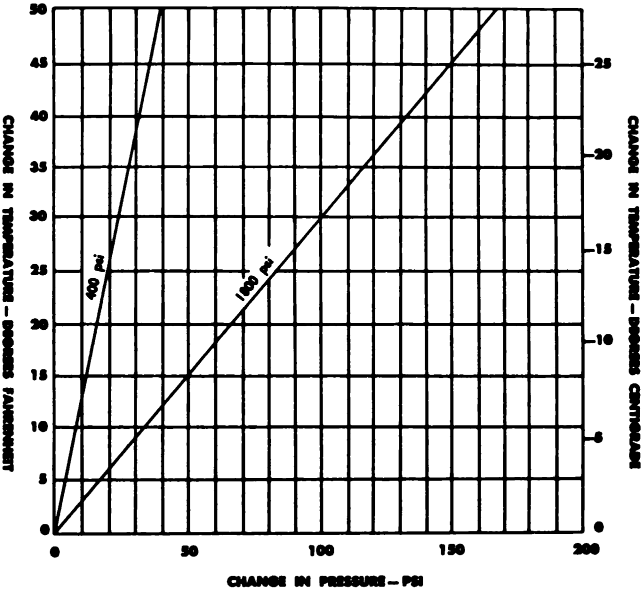
205-cubic inch cylinder	120 p. s. i.
295-cubic inch cylinder	90 p. s. i.
514-cubic inch cylinder	50 p. s. i.

To determine allowable pressure drop for oxygen systems utilizing more than one cylinder of the above sizes and/or more than one oxygen regulator, the allowable pressure drop for a single cylinder/regulator installation should be divided by the number of cylinders used and multiplied by the number of regulators installed in the system.

Example: Three 514-cubic inch oxygen cylinders; two oxygen regulators. Allowable pressure drop for system utilizing one 514-cubic inch cylinder with one oxygen regulator is 50 p. s. i.; therefore, the allowable pressure drop for a 24-hour period is

$$50 \times \frac{2}{3} = 33.3 \text{ p. s. i.}$$

Allowance should be made for temperature change between start and finish of the test period before determining the pressure drop. Such correction is approximately 3.5 p. s. i. increase for each degree (Fahrenheit) rise in temperature; and approximately 3.5 p. s. i. decrease for each degree (Fahrenheit) drop in temperature. (See fig. 2–20.)



Correction of Pressure during leakage test for change in temperature. Add pressure change if temperature rises. Subtract pressure change if temperature falls. Graph is applicable for starting temperatures of approx +70°F (+21°C).

Figure 2–20.—Pressure change due to temperature change. High-pressure and low-pressure gaseous system.

The heat of compression affected by changing operations, causes the temperature of the oxygen in the cylinder and system to rise. Consequently, the filling pressure should not be used in determining system leakage. See chapter 6 for correct filling pressures at various temperatures to obtain an equivalent of 1,800 p. s. i. at 70° F.

A typical test for system leakage using two 514-cubic inch capacity cylinders follows:

Suppose the temperature at the time of filling the system was 70° F. To attain 1,800 p. s. i. under this temperature condition, the filling pressure would have to be 1,925 p. s. i. After a relatively short cooling-off period, the cylinder pressure would level off at 1,800 p. s. i. providing the temperature of 70° F. did not change. Now, at the beginning of the test which is to extend over a 24-hour period and for the sake of an example, consider the ambient temperature as being recorded as 70° F. and the system pressure as 1,800 p. s. i. When, at the end of this testing period, the temperature has dropped to 40° F. and the pressure reading is recorded as being 1,685 p. s. i., leakage in the system must be considered within limits.

A pressure reading of 1,685 p. s. i. at 40° F. is equivalent to 1,790 p. s. i. at 70° F. At the start of the test, the pressure recording registered 1,800 p. s. i. at 70° F.; therefore, the difference between 1,790 and 1,800 p. s. i. (10 p. s. i.) is considered as being lost through leakage in the system. The allowable leakage for this particular system has been established as being 25 p. s. i.; therefore, the 10 p. s. i. lost is within limits.

Remember, the pressure gage is the only instrument available to indicate the amount of oxygen in the system. For any system a high pressure will indicate that there is more oxygen in the system than would be there if the pressure reading were low. A loss of a given volume of oxygen from a small cylinder will result in a larger pressure drop in that cylinder than the loss of the same volume from a larger cylinder. The same principle applies when several cylinders, all the same size, are connected to a common

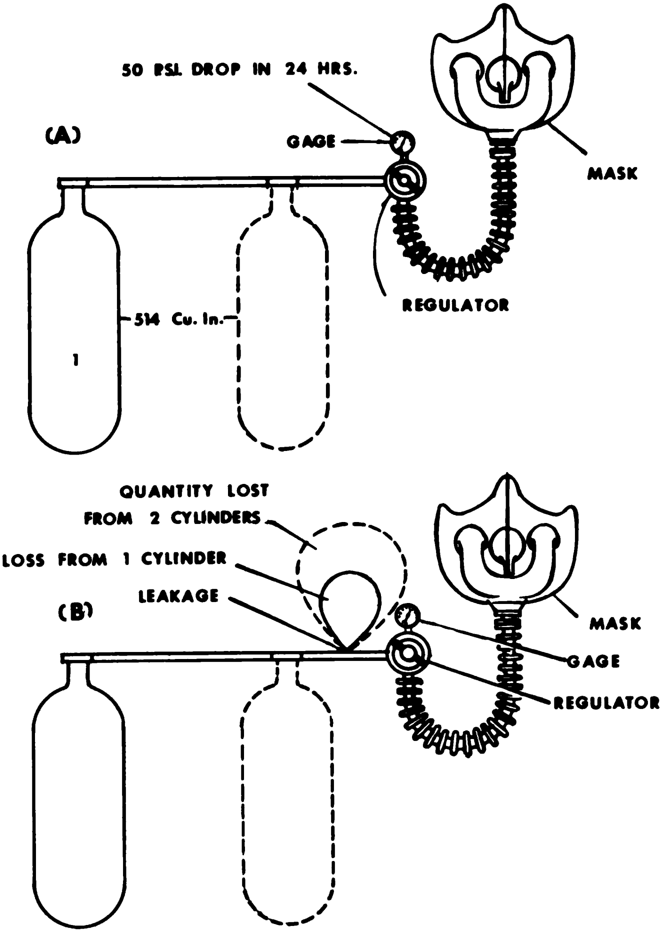


Figure 2–21.—Permissible system leakage.

system. Therefore, a leakage of 50 p. s. i. registered on a common gage for two 514-cubic inch cylinders is twice as great as it would be for one cylinder. Thus, this is the necessity for dividing the number of cylinders installed by their numerical application in order to compare the permissible leakage established for one cylinder.

Figure 2–21 illustrates the principles involved in permissible system leakage. A system with only one 514-cubic inch cylinder, (1) in figure 2–21 (A), can lose 50 p. s. i. over a 24-hour period while the same system equipped with two 514-cubic inch cylinders can lose only 25 p. s. i. over a 24-hour period in order to provide twice the expected duration of one cylinder. Figure 2–21 (B) illustrates the quantity of gas lost through leakage by two 514-cubic inch capacity cylinders. This leakage results in TWICE THE VOLUME of gas lost for the same gage pressure drop, critically lessening the duration of an expected greater capacity system.

Ground-Crew Check for Regulators

That portion of the ground-crew check specifically affecting oxygen regulator operation follows:

SYSTEM PRESSURE.—If the system is fully charged, the pressure gage should read 1,800±50 p. s. i. at 70° F., or equivalent. No aircraft equipped with an approved oxy-

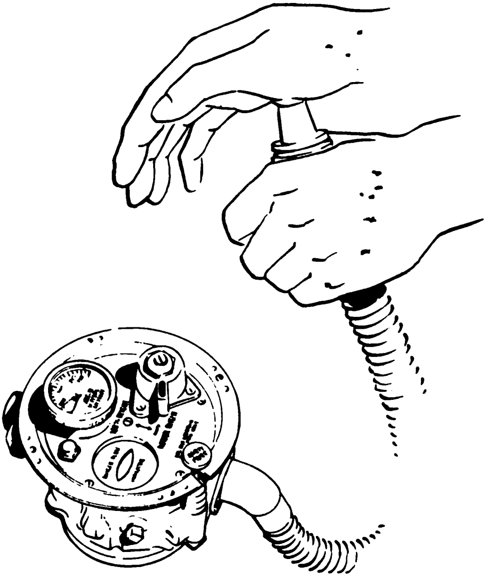


Figure 2–22.—Regulator leakage test.

gen system is released for flight above 10,000 feet unless sufficient oxygen is available in the system to meet all operational requirements.

REGULATOR LEAKAGE TEST.—Test (all regulators except automatic positive pressure and composite regulators having a suffix B–1) by obstructing the outlet of the oxygen breathing tube. (See fig. 2–22.) If the flow indicator face opens in less than 30 seconds, excessive leakage exists and the regulator should be replaced. Inspect models 2862, 2863, and 2864 regulators to insure that the emergency valve handles have been removed.

DEMAND VALVE AND OXYGEN FLOW INDICATOR OPERATION.—With the supply pressure ON, fully depress or turn manually the SAFETY-PRESS button, arm, or regulator diaphragm. Oxygen should flow at the open end of the breathing tube. (See fig. 2–23 (A).) If no flow is noted, the regulator is defective and must be replaced. Release SAFETY-PRESS button, arm, or diaphragm, depending on the type of regulator. If oxygen flow does not stop immediately, the regulator should be replaced. Set air valve to 100-PERCENT OXYGEN (fig. 2–23 (B)) and inhale through breathing tube and regulator. If excessive resistance to inhalation is noted, replace the regulator. If oxygen flow is obtained during the above tests, but the flow indicator does not blink, replace the flow indicator if mounted separately, or replace the regulator if it is the composite type.

REGULATOR DIAPHRAGM, DILUTER CHECK VALVE, AND BREATHING-TUBE SYSTEM LEAKAGE.—Test by inserting a spare mask tube quick disconnect (AN6043) into the open end of the disconnect. Blow into the open end of the disconnect until the flow indicator face opens. Seal the end of the disconnect with the tongue. If the flow indicator does not close within 3 SECONDS, the leakage is within acceptable limits. If leakage exists, check the couplings (AN6004 series), outlet elbow, and breathing-tube clamps for tightness. (See fig. 2–24.)

DEFECTIVE (EXPANDED) AIR VALVE ANEROID.—With the supply pressure ON and the air valve set to 100-PERCENT

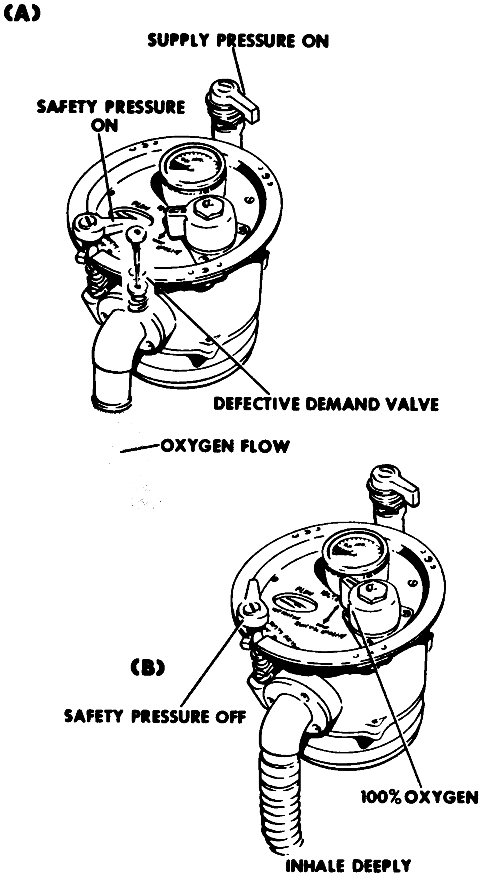


Figure 2–23.—Demand valve and oxygen flow indicator operation.

OXYGEN, manually operate the SAFETY PRESS control or the regulator diaphragm, if accessible. With oxygen flowing, turn the air valve control to NORMAL OXYGEN and listen for a difference in the sound of oxygen flow. (See fig. 2–25.) If NO difference in sound can be detected, the air valve aneroid may be defective and the regulator must be bench checked. If the regulator diaphragm cannot be depressed manually because of a protective plastic cover being installed over the face of the regulator case, connect a mask to the quick dis-

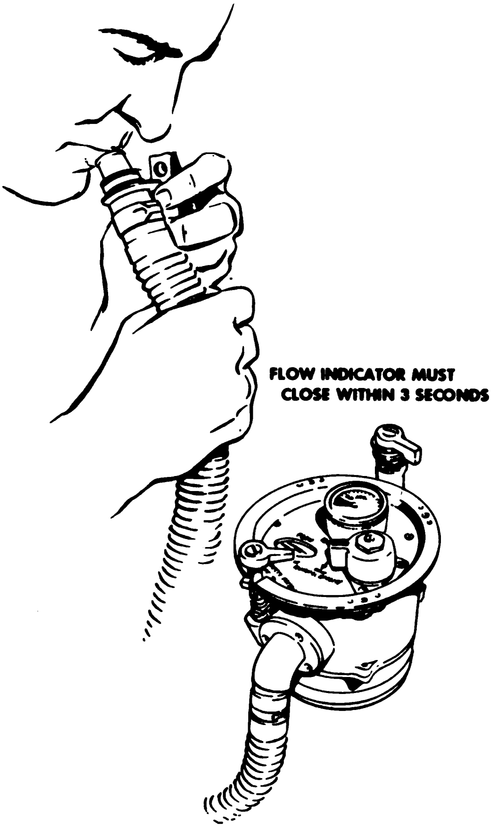


Figure 2–24.—Regulator diaphragm, diluter check valve, and breathing-tube system leakage.

connect and breathe through the regulator. By breathing through the regulator, experienced personnel will be able to distinguish a different "feel" or sound of the oxygen flow as the air valve control is switched back and forth from the 100-PERCENT OXYGEN to the NORMAL OXYGEN positions. Sometimes distracting noises of other aircraft warming up in the vicinity makes this latter testing method necessary.

EMERGENCY VALVE OPERATION FOR REGULATOR MODEL 2858 AND SIMILAR MODELS.—With supply pressure ON, open the regulator emergency valve, and feel if there is oxygen

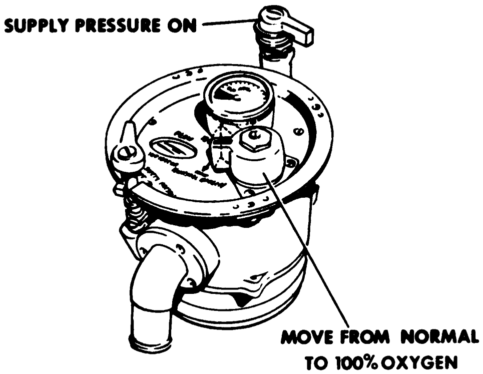


Figure 2–25.—Defective expanded air valve aneroid.

flow at the open end of the breathing tube. If no flow is noted, close the emergency valve and replace the regulator. Never obstruct the flow of oxygen; to do so will damage the regulator.

Preflight and Operating Procedures

The preflight test for diluter-demand oxygen systems is supplementary to the ground-crew test and is performed by pilots and airmen in preparation for high altitude flight. The Parachute Officer, in conjunction with the Parachute Rigger, is responsible under the commanding officer to properly indoctrinate personnel with the use of their oxygen equipment. Therefore, it is important that the Parachute Rigger be familiar with the following preflight procedure.

Preflight test.—Prior to flight in which oxygen is to be used or likely to be used, pilots and aircrewmen should check and set the emergency valve to the off (2858 Models) position.

The pressure gage should read 1,800 ± 50 p. s. i. if the cylinder is fully charged. Be sure to read the proper gage on a reduced high-pressure system. Aircraft equipped with the automatic opening high-pressure oxygen cylinder valves do not require manual operation. If cylinders are provided with valve and handwheel, turn on the supply pressure. Regulators equipped with a shutoff valve will have to be turned on.

The cylinder pressure shall not drop more than 50 p. s. i. in 24 hours after due allowance for temperature corrections of 3.5 p. s. i. per degree Fahrenheit. If the cylinder has a valve with a handwheel, turn off the supply pressure. After a few minutes observe the pressure gage and simultaneously turn on the supply pressure. If the gage pointer JUMPS, leakage is indicated and the system shall again be subjected to the GROUND-CREW TEST prior to use.

Place the quick-disconnect coupling of the breathing tube to the lips and blow into the open end. If there is no obstruction to exhalation, leakage in either the regulator, outlet elbow, or breathing tube exists. Check the regulator outlet and hose clamps on both ends of the breathing tube for tightness; this operation may require the removal of certain panels, and will take an appreciable amount of time. If, after tightening these units, the leak still persists, replace the regulator.

Put on the mask—pressure type mask for use with pressure systems, regular type mask for use with systems not equipped with safety pressure features. Check regular mask fit by placing the thumb over the disconnect at the end of the mask tube and INHALE LIGHTLY. If there is no leakage, the mask adheres tightly to the face and a definite resistance to inhalation is encountered. If the mask leaks, tighten the mask suspension straps, and bend the nose wire, readjusting the contour of the mask around the bridge of the nose. For the pressure type mask, check the fit by putting on the oxygen mask and attaching the helmet as in flight. Connect the oxygen mask to the regulator coupling or quick disconnect and actuate the manual safety pressure. Take a deep breath and hold it. While holding the breath note the position of the flow indicator. If the flow indicator opens (all black), a leak is indicated. Tighten the mask straps until the flow indicator closes (white face). Resume breathing and release the manual safety pressure. DO NOT USE A MASK THAT LEAKS.

Fully engage the mating portions of the disconnect coupling to connect the mask to the oxygen system breathing tube.

Breathe several times with the regulator air valve in both NORMAL OXYGEN and 100-PERCENT OXYGEN positions to check the regulator operation and observe the oxygen flow indicator for "blink." This verifies the positive flow of oxygen. When pilots and aircrewmen experience difficulty during exhalation, while using a pressure mask (at sea level), it is most probable that dirt and dust has collected under its inhalation valves. Foreign matter under these inhalation valves prevents them from properly closing off the inhalation ports. A back pressure through an inhalation port created by the individual attempting to exhale will be directed against the underside of the compensating exhalation valve, thereby preventing its opening. Because a pressure type mask will not operate properly when dirty, extra care must be exercised in keeping it exceptionally clean.

FLIGHT OPERATING PROCEDURE.—When oxygen is used during flight, the following procedure is used:

Turn on the oxygen supply pressure. The pressure gage should read 1,800 ± 50 p. s. i. if the cylinder is fully charged, and if the temperature is at 70° F., or equivalent.

Put on the mask. Fully engage the mating portions of the disconnect coupling to connect the mask to the oxygen breathing tube. Attach the clip of the breathing tube to clothing so it will not foul in the shoulder harness. This will also permit free movement of the head without stretching of the mask tube. When using a bail-out connector, the web tab provided with the connector should be attached in a secure position on the pilot's person.

To check mask fit during flight, actuate the manual safety pressure control. Take a deep breath and hold it. Note the position of the oxygen flow indicator. If the flow indicator opens, excessive leakage is indicated. Tighten the mask straps until the flow indicator closes. The characteristics of the flow indicator are such that this test cannot be conducted at pressure-breathing altitudes; however, the outward flow of oxygen into the eyes from a leaking mask is readily detectable and is an equally sensitive test. Check the mask fit of the regular type by squeezing the mask tube and inhaling lightly.

If there is no leakage, the mask will adhere tightly to face due to suction. If the mask leaks, tighten the mask suspension straps and/or adjust the nose wire.

When breathing oxygen, flight check the following items:

1. Cylinder pressure gage for oxygen supply.
2. Oxygen flow indicator for flow of oxygen through the regulator.
3. Mask fit for leaktightness.
4. Insure engagement of disconnect couplings.
5. Connection of bail-out bayonet fitting to bail-out connector.

Upon completion of flight, turn off the oxygen supply and set the air valve to the 100-PERCENT OXYGEN position. Closing off the air valve will help prevent odors from entering the regulator while the aircraft is not in flight. Properly secure the end of the breathing tube. The flap cover should be closed, and the end of the tube should be stowed out of the way.

EMERGENCY CONDITIONS DURING FLIGHT.—If emergency conditions prevail during flight, the instructions below shall be followed:

If symptoms should occur which suggest the onset of hypoxia, immediately activate the safety pressure control or emergency valve, as applicable to the regulator. If the regulator should become inoperative and a constant pressure or flow of oxygen is not obtained by use of either the safety pressure control or emergency valve, disconnect the breathing tube, activate the oxygen bail-out equipment, and descend below 10,000 feet.

Whenever excessive carbon monoxide or other noxious or irritating gas is present or suspected, regardless of altitude, the air valve should be set at the 100-PERCENT OXYGEN position, and undiluted oxygen used until danger is past or the flight is completed.

MASK REMOVAL AT HIGH ALTITUDE.—Should brief removal of the mask from the face be necessary at high altitude, take three or four deep breaths of 100-percent oxygen with the air dilution valve lever set to OFF position; hold the breath and remove the mask from the face; as soon as practicable, replace the mask to the face and take three or four deep breaths of 100-percent oxygen; and reset air valve lever to ON or NORMAL OXYGEN position.

Automatic Continuous-Flow Oxygen Regulators (Types A-11 and AN6010-1)

DESCRIPTION.—Automatic continuous-flow oxygen regulators are used to provide automatically a continuous flow of oxygen, varying with altitude, to 15 or less passengers in troop-transport airplanes. The instrument automatically regulates the flow of oxygen at all altitudes from 10,000 to 30,000 feet and above and at oxygen cylinder pressures ranging from 50 to 500 p. s. i. No manual control is necessary, or provided with these regulators.

Construction of both automatic continuous-flow oxygen regulators is similar. Variations in model number designate different methods of manufacture (body construction and valving).

OPERATION.—The automatic continuous-flow oxygen regulators are designed to deliver a predetermined oxygen flow to each passenger by maintaining or regulating a line pressure of the proper magnitude to produce the specified flows through 0.016-inch diameter orifices.

As oxygen first enters the regulator (fig. 2–26), all foreign particles that might impair regulator performance are removed by the screen (20), and oxygen pressure increases in the first-stage chamber until the regulating bellows assembly (12) is compressed to a point where an additional pressure increase will close the valve (18) and a pressure decrease will open this valve, tending to maintain the pressure of oxygen leaving the first stage at a constant value. Actually, first-stage outlet pressures, while maintained within narrow predetermined limits under all conditions of operation, are not constant due to changes in force exerted directly on the valve itself by varying cylinder pressures.

Oxygen pressures in the second stage are regulated by the actuating bellows assembly (29) which opens and closes the second-stage valve mechanism to maintain a pressure corresponding to the spring force on the atmospheric side of the bellows.

To meet the increasing oxygen flow requirements as the airplane gains altitude, the compensating bellows assembly (25) provides an increasing spring force on the actuating bellows (29) which in turn will maintain a corresponding increased delivery of outlet pressure. The spring force on the actuating bellows varies with altitude, due to the removal or addition of atmospheric pressure on walls of the spring-loaded, evacuated compensating bellows, and the total spring force (being constant) will exert a force on the actuating bellows depending on the magnitude of the atmospheric pressure force acting against it.

A safety valve (43) is incorporated in the first-stage body wall and serves as a protection againt leaks or failure of the first-stage bellows (12) to regulate properly. There is no adjustment provided for this safety valve since it is permanently set by the manufacturer.

After the regulator is properly installed, operation is entirely automatic.

When oxygen masks are not being worn, always keep them disconnected from the automatic coupling. Failure to do this will result in an unnecessary loss of oxygen, as a small amount of oxygen is delivered by the regulator even at sea level. (See fig. 2–26.)

INSTALLATION.—Installation of the regulator must be made in accordance with the installation drawings for the particular airplane. (Refer to applicable airplane handbooks and drawings.) Each regulator is fastened to the mounting panel with the four machine screws, nuts, and lockwashers supplied.

Under no circumstances is the INLET to the automatic continuous-flow oxygen regulator to be installed to an oxygen source of greater than 500 p. s. i.

Under no circumstances is the OUTLET of the automatic continuous-flow oxygen regulator to be connected to an oxygen source which will create a pressure on the outlet side of the regulator greater than 30 p. s. i.

Be sure that all moisture and foreign particles are removed from the oxygen lines before the regulator is installed.

Before the oxygen regulator is installed on any oxygen

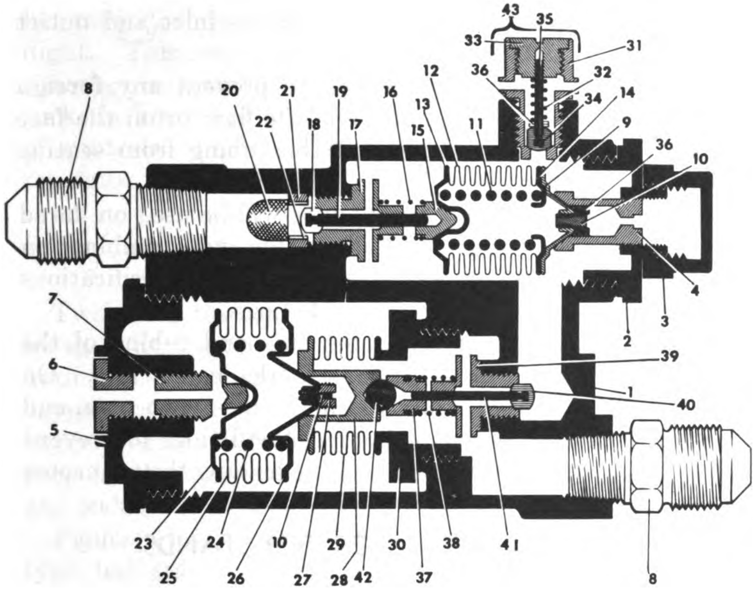


Figure 2–26.—Detailed assembly showing index numbers of parts—automatic continuous-flow oxygen regulator.

1. Body.
2. Cap, body, 1st stage.
3. Cap, adjustment, 1st stage.
4. Screw, adjustment, 1st stage.
5. Cap, body, 2nd stage.
6. Cap, adjustment, 2nd stage.
7. Screw, adjustment, 2nd stage.
8. Fitting, AN816–5D.
9. Adapter, male.
10. Plug, evacuating.
11. Spring, bellows.
12. Bellows (regulating).
13. Adapter, female.
14. Guide, spring.
15. Cone, centering.
16. Spring, valve.
17. Housing, valve.
18. Valve and pin subassembly.
19. Pin, valve.
20. Screen.
21. Washer, synthetic rubber.
22. Ring, reinforcing.
23. Adapter, female.
24. Spring, bellows.
25. Bellows (compensating).
26. Adapter, male.
27. Adapter, evacuating.
28. Connector.
29. Bellows (actuating).
30. Adapter, sealing.
31. Housing, valve, safety.
32. Spring, valve, safety.
33. Cap, valve, safety.
34. Valve and pin subassembly.
35. Pin, valve, safety.
36. Washer, valve pin.
37. Adapter, centering.
38. Spring, valve.
39. Housing, valve.
40. Valve and pin subassembly.
41. Pin, valve.
42. Ball, thrust.
43. Valve assembly, safety.

system, the system should be tested to be sure that it complies with the applicable leakage specifications.

Remove the plastic dust caps from the inlet and outlet fittings.

Extreme care must be exercised to prevent any foreign substance gathering on the inside of the flare or on the face of the fitting as this will prevent the tubing from seating satisfactory against the fitting.

No antiseize and sealing compounds will be used on flared tube fittings with straight threads. However, combination antiseize and sealing compounds conforming to specifications can be used on tapered pipe thread fittings.

Attach 5/16-inch tubing connector nuts and tubing of the oxygen supply system to inlet and outlet connectors. On attaching the connector nuts to the fittings, two open-end wrenches should be used; one holding the fittings to prevent further tightening in the body, and one holding the connector nut.

OXYGEN REGULATOR TEST STANDS

Two important points previously stated should be recalled at this time. A diluter-demand type regulator is a metering device. It can automatically mix air with oxygen passing through in the required amounts consistent with varying atmospheric pressure. The oxygen-air mixture is controlled by pressure differences. A high degree of mechanical sensitivity and good working order is required for reliable operation 100 percent of the time—failure of the device and/or its major components means death at high altitudes.

While the ground-crew check is designed to test the mechanical operation of an oxygen regulator and system, it cannot detect all functional defects that might occur during operation. The ground-crew check does not entail the use of apparatus that can actually measure true performance. It shows primarily that the regulator is connected to its source of oxygen supply, and that a quantity of oxygen and/or air is passing through to the user.

While the importance of a ground check cannot be overemphasized, there are other serious more elusive factors that affect the operation of a regulator. To test a regulator COMPLETELY before using it under actual conditions, it must be subjected to the effects of simulated high altitude flight. This requires the use of a miniature decompression chamber, an evacuating source (a vacuum pump to draw or suck the air out of the chamber), instruments, and a system of controls. Such a testing device is termed an oxygen regulator test stand.

ARO Test Stands

Two of the test stands used in the Navy are manufactured by the ARO Equipment Corporation. The DEMAND OXYGEN REGULATOR TEST STAND is designed to test all demand type oxygen regulators, including pressure breathing demand oxygen regulators for flow capacities, oxygen concentrations, pressure characteristics (safety pressure and pressure backs), and leakage at desired test altitudes.

Figures 2–27 through 2–29 illustrate flowmeter and canister type test stands. The older model (OT–122C) is usually modified locally, as the suction manometer provided with the stand offers little latitude for movement of the liquid. Because of this, it is easy to actuate the manometer fluid past the limits of the scale down into one of the glass wool-packed canisters. To avoid this trouble, the stand can be modified as shown in figure 2–28. The modification includes replacement of the plastic tubing by aluminum tubing. When this happens, it is necessary to remove the canister affected. After replacing the canister, the test stand must be recalibrated before being used again.

MAJOR COMPONENTS.—A general component outline for test stands OT–122C and C11250 follows:

The airtight CHAMBER, when partially evacuated by the suction source (vacuum pump), provides reduced atmospheric pressures which stimulate altitudes for testing purposes. Located inside the chamber are connections for the regulator to the source of oxygen and to the vacuum line.

The CONTROL VALVES are of the needle type and should not be closed too tightly. VALVE A is used to control the

AIR-OXYGEN FLOW through the regulator, VALVE B to control the AIRFLOW into the chamber, and VALVE C to EVACUATE the chamber directly.

The CANISTERS (two) are the linear elements that make it possible to measure the INPUT and OUTPUT flows. Each canister is leakproof and packed with glass wool. Leakage of the canister or any kind of disturbance of the glass wool packing will affect the accuracy of previous calibrations.

The PIPING used in the construction of the flow system is standard wrought iron throughout. The oxygen supply and auxiliary vacuum piping system is $\frac{5}{16}$-inch copper tubing.

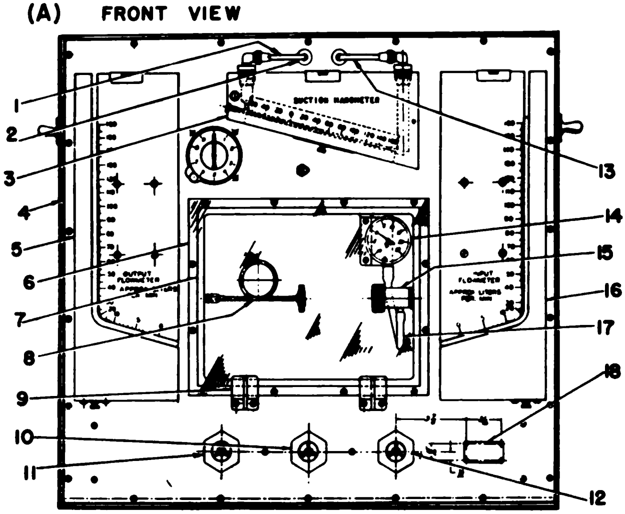


Figure 2-27.—(A) Demand Oxygen Regulator Test Stand, OT-122C—front view.

1. Plastic tubing assembly (pressure line to suction manometer).
2. Rubber grommet.
3. Suction manometer.
4. Test stand frame and panel assembly.
5. Output flowmeter.
6. Vacuum chamber cover.
7. Vacuum cover gasket.
8. Inlet tubing assembly.
9. Support assembly for chamber cover.
10. Needle valve C.
11. Valve A.
12. Valve B.
13. Plastic tubing assembly (vacuum line to suction manometer).
14. Vacuum pressure gage.
15. Outlet fitting assembly.
16. Input flowmeter.
17. Hose for vacuum pressure gage.
18. Nameplate.

(B) REAR VIEW

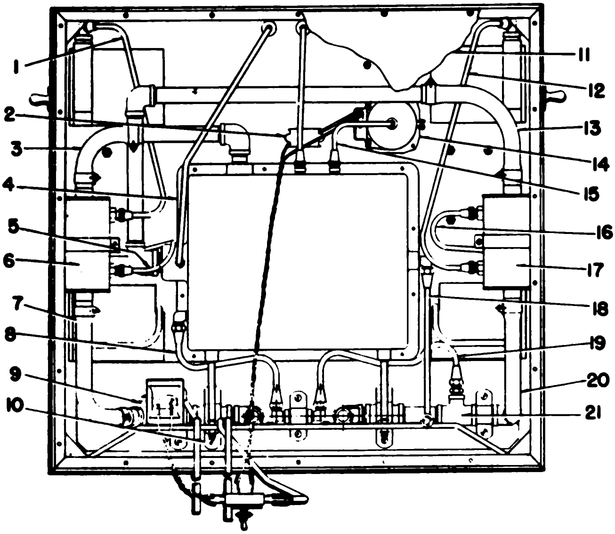


Figure 2-27.—(B) Demand Oxygen Regulator Test Stand, OT-122C—rear view.

1. Plastic tubing assembly (input flowmeter suction side).
2. Transformer and switch assembly.
3. Rubber tubing assembly (element to chamber).
4. Chamber assembly.
5. Plastic tubing assembly (flowmeter pressure side).
6. Linear resistance type flowmeter element (canister).
7. Rubber tubing assembly (air-in).
8. Auxiliary vacuum line (valve to chamber).
9. Manifold assembly (air-in).
10. Galvanized pipe strap (valve to panel board).
11. Rear panel.
12. Plastic tubing assembly (flowmeter suction side.)
13. Rubber tubing assembly (vacuum element to chamber).
14. Altimeter and buzzer assembly.
15. Plastic tubing assembly (chamber to altimeter).
16. Plastic tubing assembly (flowmeter pressure side).
17. Linear resistance type flowmeter element (canister).
18. Oxygen pressure tubing assembly.
19. Auxiliary vacuum line (valve C to vacuum line).
20. Rubber tubing assembly (vacuum line).
21. Vacuum manifold assembly.

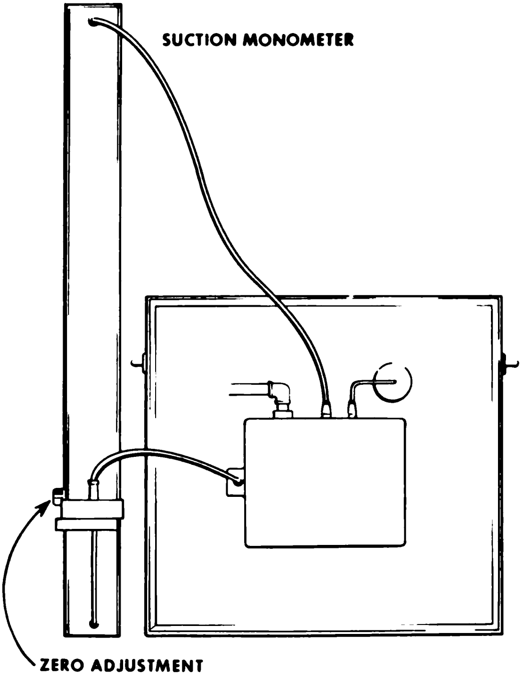


Figure 2–28.—Demand Oxygen Regulator Test Stand, OT–122C—locally modified.

The flowmeter tubing is constructed of ¼-inch Saran plastic or rubber.

There are two FLOWMETERS. One is used to measure the flow of air drawn into the chamber, the other measures the flow of air and oxygen through the regulator. They are of the linear resistance type. The pressure drop created across a canister packed with glass wool measures the flow. They have a range of 10 inches of water, and are calibrated in liters per minute (l. p. m.). (For testing purposes, 150 l. p. m. comprises the full scale; however, each flowmeter is graduated to 160 l. p. m.)

The SUCTION MANOMETER used in test stand OT–122C is calibrated from +0.60 to −1.60 inches of water. It is used to measure the suctions required to obtain the specified flows from the regulator. In comparison, test stand C11250

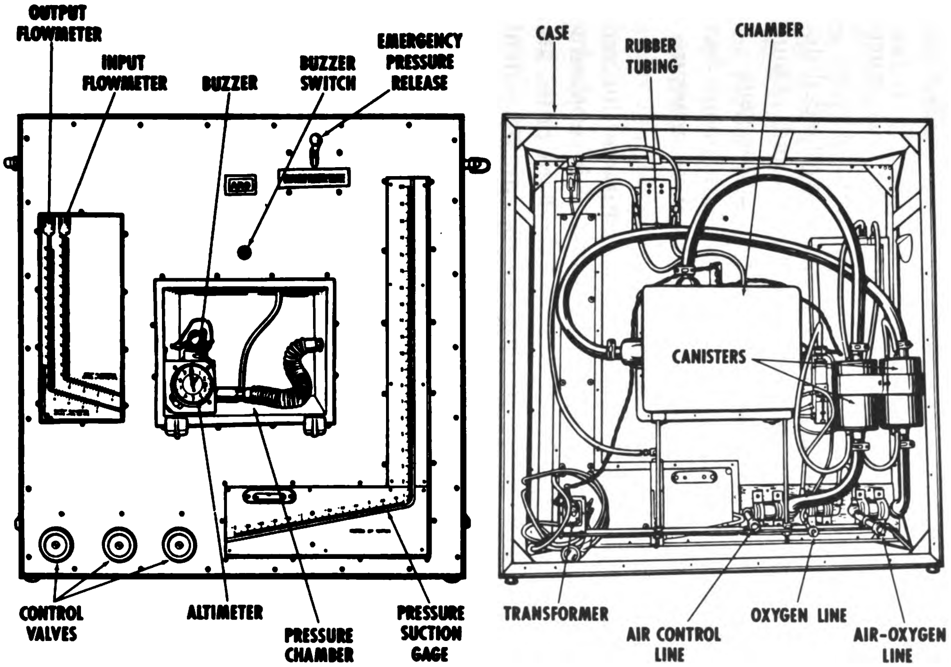


Figure 2-29.—Demand Oxygen Regulator Test Stand, Type C11250.

is calibrated to 2 inches of suction and 20 inches of pressure.

The COMBINATION PRESSURE-SUCTION GAGE (used only in test stand OT-122C) is calibrated from 25 inches of water to 10 inches of vacuum (suction). · It is used to measure suction from the outlet of the regulator or the pressure applied inside.

Caution: When this gage is not in use, disconnect it from the outlet pipe and plug the line into the pipe. Disconnected, the gage cannot be accidently overloaded during normal testing. Local modification of test stands eliminates the suction manometer and the pressure suction gage.

The aircraft ALTIMETER is a sensitive instrument, having a range of 0 to 50,000 feet. It is used to measure the simulated pressure-altitude.

The BUZZER is used to vibrate the altimeter to reduce frictional errors. The buzzer wiring system is supplied with a double-pole double-throw switch at the back of the stand. With this switch, it can be operated on either 6-volt d. c. or 110-volt, 60-cycle a. c. by changing the position of the switch and connecting the proper outlet wire.

The CASE serves as the framework or mounting structure for all the components. Each case is equipped with a face cover which, when in place, protects the fragile flowmeters, chamber glass cover, and other instruments from damage.

While the VACUUM PUMP is necessary in the operation of simulating altitudes in the testing chamber, it is not an integral part of the test stand. The pump is mounted separately, usually outside the room occupied by the test stand, and is connected to a vacuum line or pipe leading to the back of the stand. The suction capacity of the pump must be sufficient to lower the pressure in the chamber to that of the specified altitude. In order to test a regulator throughout its full operating range, the vacuum source must measure up to the task.

TRACING THE FLOW.—In tracing the flow through valve B, air enters the tubing of valve B and goes into the lower part of the canister connected to the input flowmeter. As the air goes through the canister, the pressure drops. Outlets at the bottom of the input flowmeter and bottom of the canister are connected. Another outlet at the top of the canister connects to the top of the input flowmeter. Pressure pushes the fluid in the flowmeter upward. (If the same amount of pressure came through the top of the canister, the fluid would remain at zero.) The amount of pressure drop is indicated on the input flowmeter in liters per minute. The air entering the chamber through valve B must be removed from the chamber through valve A.

The flow through valve A is the flow of air and oxygen through the regulator (provided, of course, that the air valve of the regulator is open). Valve A is located between the outlet of the regulator and the vacuum. With valve A open, the total flow of air and oxygen going through the regulator goes through tubing to the top of the canister connected to the output flowmeter. Tubing from the top of this canister is connected to the bottom of the output flowmeter, and the tubing from the bottom of the canister is connected to the top of the output flowmeter. The presure drop is indicated by the amount the fluid rises. This is the total flow of air and oxygen through the regulator, and is measured in liters per minute. After the total flow passes through the outlet canister, it passes into the vacuum line.

ADJUSTING AND TESTING THE STAND.—Before testing a regulator, the test stand must be checked for leakage and calibration. It may also be necessary to make a number of minor adjustments before actually operating the stand. This does not imply that every test stand must be checked every time before another regulator can be run through a testing sequence. One must use his judgment as the following factors illustrate:

1. After a stand has been set up, it must be checked very carefully for leakage and calibration.

2. Occasionally, the fluid in the flowmeter needs replenishing or the flowmeters may not be perfectly level.

3. After a repair to any part of the stand, it must be leak tested and checked for calibration.

4. Whenever a stand is in daily use, it should be checked for leakage and calibration at the beginning of each day's

operations. Do not permit familiarity with any one piece of equipment to breed carelessness. Be on the alert by being willing to recognize and question oddities in operation which might present themselves in sounds, vibrations, or other movements.

The flowmeters and suction manometer are equipped with levels which should be leveled before any zero oil adjustments are made. The flowmeters normally read zero and should return to zero when not in operation. An adjustment is provided to reset them. If the flowmeters do not read zero, reset them to zero by moving the knurled head screw located at the bottom of the flowmeter in the direction required to bring the oil to zero. (See fig. 2–30.)

If there is not enough oil to make a zero adjustment, add red oil to bring it to a zero level. Use oil having a specific

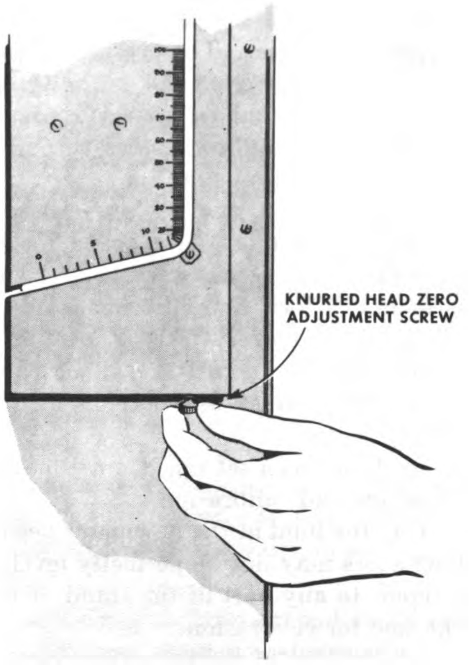


Figure 2–30.—Adjustment of oil level.

gravity of 0.835 ± 0.003. The suction manometer can be adjusted by unscrewing the knurled head screw lock to loosen the scale. Adjust the scale to read zero and tighten the lock screw.

The altimeter should be set so that the barometric pressure reading is 29.92 inches of mercury. This setting is not to be changed.

If the pressure suction gage does not read 0 ± 0.5, it should be replaced, as its construction prohibits normal field repairs.

To test the stand for leakage, after checking all connections for tightness, plug the end of the oxygen line in the chamber using any adaptable capped fitting. This fitting, in all probability, will have to be constructed locally. It must be leakproof. Place the heavy glass cover in its supports in front of the chamber, pressing it against the gasket. Start the vacuum pump by actuating an electric switch. Turn on the buzzer, MAKING CERTAIN VALVES B AND C ARE CLOSED. Slowly open valve A. Evacuate the air in the chamber to a simulated altitude of 30,000 feet. After the evacuation process has begun, the pressure of the air outside the chamber will press the glass cover against the chamber gasket. Every square inch of the cover has 14.7 pounds per square inch reacting on the outside, while inside the chamber surface, the pressure is reducing in proportion to the pressure of the simulated higher altitudes. Close valve A, and observe the altimeter for one minute. After one minute's time, the decrease in altitude should not be more than 200 feet. Recheck connections for tightness and poor flares on the tubing if leakage was excessive; but before doing this, bring the chamber back to sea level by opening valve B slowly. Remove the glass cover.

In checking the calibration of the flowmeters, a standard ORIFICE and CALIBRATION CHECK CHART are two items of paramount importance. The orifice fitting contains an air opening or small aperture which has been drilled to a specific size. It is used to restrict the much larger opening where the regulator outlet is normally connected in the chamber. (See fig. 2–31.) Without this restricting aperture, calibration operations. Do not permit familiarity with any one piece of equipment to breed carelessness. Be on the alert by being willing to recognize and question oddities in operation which might present themselves in sounds, vibrations, or other movements.

The flowmeters and suction manometer are equipped with levels which should be leveled before any zero oil adjustments are made. The flowmeters normally read zero and should return to zero when not in operation. An adjustment is provided to reset them. If the flowmeters do not read zero, reset them to zero by moving the knurled head screw located at the bottom of the flowmeter in the direction required to bring the oil to zero. (See fig. 2–30.)

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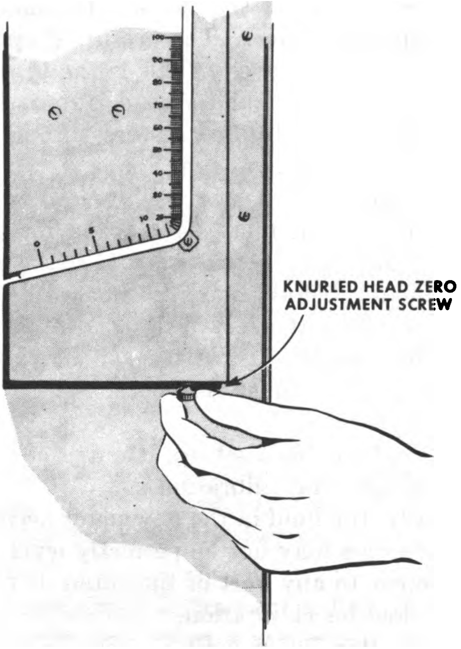

Figure 2–30.—Adjustment of oil level.

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In checking the calibration of the flowmeters, a standard ORIFICE and CALIBRATION CHECK CHART are two items of paramount importance. The orifice fitting contains an air opening or small aperture which has been drilled to a specific size. It is used to restrict the much larger opening where the regulator outlet is normally connected in the chamber. (See fig. 2–31.) Without this restricting aperture, calibration would not be possible. Once the orifice has been used in constructing a calibration chart (l. p. m. flow figures for different altitudes), directly involving the flow characteristics of the canisters, the orifice and chart must remain with the test stand.

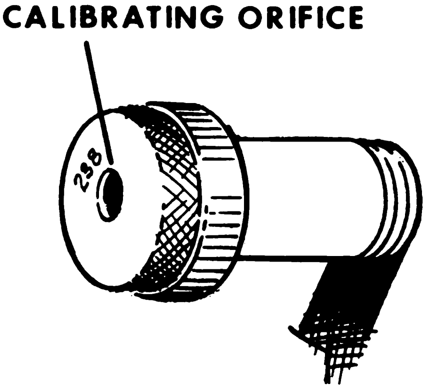


Figure 2–31.—Application of the calibrating orifice.

To check the calibration of the flowmeters, plug the oxygen supply line in the chamber. Attach the orifice to the outlet fitting so leakage cannot occur around the connection. Slowly open valve A and set the suction manometer to 1.6 inches of water. The output flowmeter should indicate the value shown on the chart furnished with the test stand and orifice. For example, with 1.6 inches of suction at SEA LEVEL, the output flowmeter reading must be between 60.25 and 70.75 l. p. m. (See table 2–3.) At 20,000 feet (glass cover on stand), with 1.6 inches of water suction, the output and input flowmeters must read between the values shown on the calibration check chart. Record the ACTUAL readings on a duplicate check chart for filing. In operating the test stand, the altitude is balanced off by manipulating valve B. The upper and lower flowmeter figures shown on the chart (96 lower and 104 upper for the output flowmeter at 20,000 feet) represent an acceptable range computed as 99.84 ± 4 percent (4 percent less than 99.84 equals 96, and 4 percent

Table 2-3.—Orifice calibration check chart

(122C)

Orifice No. ----------   Suction 1.6″

ALT.	INPUT		OUTPUT	
	HIGH	LOW	HIGH	LOW
S. L.	------	------	70. 75	60. 25
10M				
20M	94. 00	88. 25	104. 00	96. 00
30M				

(C11250)

Orifice No. --------   Suction 1″

ALT.	INPUT		OUTPUT	
	HIGH	LOW	HIGH	LOW
S. L.	------	------		
15M				
20M				
25M				
30M				
35M				
40M				

more than 99.84 equals 104). If the actual flowmeter readings do not remain with a ±4 percent range as represented by the upper and lower figures, the canisters must be replaced. This will also necessitate recalibrating the test stand.

Regulator Testing Procedure

After having determined that the test stand is in calibration (indicated accurate readings), the operator may proceed with the actual regulator testing steps. NOTE: All flows in the manual are INDICATED and must be changed to ACTUAL. As you have learned, all oxygen breathing regulators are bench tested in accordance with a schedule that must be followed implicitly. Of all the tests to be conducted, only one involves the use of graphs and the construction of performance charts. All other steps are simple by comparison to the OXYGEN RATIO TEST; but like all other things, once the procedure has been understood, the entire operation will seem relatively easy. Next to accuracy, the most demanding human element to be considered is patience. All these testing steps take time. They were designed by the engineers who built the equipment and who knew where the weaknesses of their mechanical operation were. In view of this, no one has a right to cut corners simply because he believes that any part of any one major step is unimportant. THEY ARE ALL IMPORTANT, AND MUST ALL BE CARRIED OUT.

INWARD LEAKAGE TEST.—The purpose of this test is to determine the amount of ambient air leaking into the case of the regulator. The procedure follows:

1. Mount the regulator in the test stand.
2. Start the vacuum pump.
3. Turn the air valve on the regulator to the 100-percent oxygen position.
4. Do NOT apply inlet (oxygen) pressure.
5. Open valve A to indicate 1 inch of water suction.
6. The amount of leakage is indicated on the output flowmeter.
7. The inward leak must not exceed 0.5 liter per minute.

SAFETY PRESSURE TEST.—The purpose of this test is to determine the amount of positive pressure delivered when the safety press is actuated. (This does not concern AN6004–1 regulators.) The procedure follows:

1. Mount regulator in the test stand.
2. Turn the air valve on the regulator to the normal position.
3. Adjust the oxygen inlet pressure to 150 p. s. i. This is done at the cylinder used to supply the test stand. All such cylinders must be equipped with manually adjustable pressure reducing regulators. The gage readings should be checked periodically for accuracy.
4. Open valve A to indicate an actual flow of 10 l. p. m. output.
5. Actuate the safety pressure.
6. The amount of pressure delivered by the regulator will be indicated on the suction manometer. The pressure as measured at the outlet of the regulator must be 1.75 ± 0.25 inches of water. If there is mechanical noise or vibration during this procedure, repeat the test. NOTE: It is recommended to increase the flow to 50 l. p. m. to determine the pressure drop. A maximum drop of 1-inch water pressure is allowable. Should the trouble continue, replace the regulator.

EMERGENCY FLOW TEST.—The purpose of this test is to determine the liters per minute output of the emergency valve. (This concerns AN6004–1 regulators only.) The procedure follows:

1. Mount the regulator in the test stand, and start the vacuum pump.
2. Turn the air valve of the regulator to the 100-percent position.
3. Adjust inlet pressure to 100 p. s. i. (2858–B1 or C1).
4. Open valve C (on OT–122C).
5. Open valve A to obtain a 40 l. p. m. output.
6. Open the emergency valve fully.
7. Slowly close valve A until the pressure suction manometer returns to nearly zero but is still on the pressure side.
8. The output flowmeter reading is the emergency flow. The flow must be 30 to 40 l. p. m.

9. Close emergency valve.
10. Close valve A.

FLOW SUCTION CHARACTERISTICS TEST.—The purpose of this test is to determine the amount of suction required to obtain the flow specified in the manual by the manufacturer of the regulator being tested. This check indicates the amount of human effort required to draw oxygen or an air-oxygen mixture from the regulator.

Flow suction characteristics are shown in table 2–4. The *Handbook Overhaul Instructions Automatic Positive Pressure Diluter Demand Oxygen Regulators* (listing 10 different Pioneer-Central type part numbers) and *Diluter Demand Oxygen Regulators* (listing 7 different Pioneer-Central type part numbers) encompasses all the information necessary for testing the regulators concerned. For other type regulators manufactured by the same company and manufactured by other companies (such as ARO) refer to their manuals for the necessary figures and testing information. When seeking new information on these handbooks, sometimes called manuals, check the *Naval Aeronautic Publications Numerical Index*, NavAer 00–500. Many of the

Table 2–4.—Flow suction characteristics for composite regulators

Inlet pressure	Minimum outlet flow (l. p. m.)	Maximum suction at outlet (in. of water)
Sea level:		
50	30	0. 45
50	40	0. 75
150	70	1. 50
15,000 ft:		
50	30	0. 45
50	50	0. 75
150	85	1. 50

manuals used by Parachute Riggers concerning oxygen regulators are listed under the 03 series in the accessories section of this publication.

The testing procedure follows:

1. The flows specified in the manual must be CHANGED to FLOWMETER readings for test stand purposes. This is done by using the OUTPUT GRAPH prepared especially for the test stand being used. The output graph, showing the CALIBRATION CURVES (lines on a graph), indicates the ACTUAL FLOW figures across the bottom, while the FLOWMETER READINGS are shown up the side. By referring to table 2–4 and the *Output Graph* (shown in the test stand handbook), workable values can be obtained and recorded.
2. Connect the regulator to the source of oxygen pressure.
3. Set the air valve in the 100-percent position, apply the pressure, set in the flow, readjust the pressure, and read the suction as indicated in the table.

PRESSURE BREATHING BACK TEST.—The purpose of this test is to determine the altitude at which the regulator is delivering a specified additional amount of pressure. The testing procedure follows:

1. Mount the regulator in the test stand, air valve set on normal.
2. Set inlet pressure to 150 p. s. i.
3. The check must be performed at an ambient flow of 10 l. p. m.; therefore, open valve A to adjust the flow.
4. Refer to *Positive Pressure Values Table* in the regulator manual for the required pressures at different altitudes, 35,000 feet and above.

OXYGEN RATIO TEST.—Oxygen ratio is the percentage of oxygen in the air-oxygen mixture that is delivered to the user. Oxygen ratio requirements vary for different altitudes and flows. With the regulator mounted in the test stand, 150 p. s. i. inlet pressure is applied while the air valve is set to the normal position. The regulator must meet the percentage requirements listed in table 2–5.

The oxygen ratio test cannot be conducted until a PERFORMANCE CHART has been prepared for the particular type

Table 2–5.—Oxygen ratio chart

Flow (at sea level in l. p. m.)	Altitude (ft.)	Allowable % oxygen	
		Min.	Max.
15	10, 000	6	35
50	10, 000	6	35
85	10, 000	6	35
5	15, 000	14	100
15	15, 000	14	42
50	15, 000	14	42
15	20, 000	24	55
50	20, 000	24	55
85	20, 000	24	65
5	25, 000	40	100
15	25, 000	40	80
50	25, 000	40	80
85	32, 000	98	100

regulator that is to be tested. To construct a performance chart which acts as a record sheet of the regulator's performance, the oxygen ratio chart (taken from the regulator manual) together with the output and input graphs are needed. For instructions on how to prepare one of these charts, refer to the applicable manual for the test stand concerned. For example, for the OT–122C refer to the *Handbook of Operation, Service, and Overhaul Instructions with Parts Catalog—Demand Oxygen Regulator Test Stand OT–122C AN 17–15BC–3*. Table 2–6 illustrates a performance chart layout.

Table 2–6.—Performance chart (oxygen ratio)

Altitude	Average oxygen concentration (in percent)	Output flowmeter readings (l. p. m.)		Input flowmeter readings (l. p. m.)				
				Actual		Indicated		Flowmeter reading
		Actual	Indicated	High	Low	High	Low	
5, 000								
5, 000								
5, 000								

Notes: Fill in the altitudes using 5,000-foot steps to 30,000 feet.
Use three flows for each altitude.
Use test stand and regulator manuals for computation.

No one can learn to operate a test stand by reading a book. You have to get out and practice each step on an actual model. The beginner should not attempt to check out a regulator for service until after his knowledge and understanding has been verified by a veteran operator. It isn't enough to know how to operate the stand. You have to know how and why a regulator acts as it does in conjunction with the instrument (test stand) simulating conditions.

A recommended testing sequence follows:

1. Pressure leakage (soap bubble) test. (This can be done in or out of the stand with at least 1,500 p. s. i. applied at this inlet.)
2. Inward leakage test.
3. Outward leakage test.
4. Emergency flow test (AN6004–1) only. With this type, the emergency flow test is the first test to be performed.
5. Flow suction test.
6. Air valve closure.
7. Oxygen ratio test.
8. Pressure breathing test (for pressure-back regulators).
9. Safety pressure test.

For information on the newer flowmeter type test stands (no canisters) made by National Instrument Laboratories, Part Number OTS–565, refer to the applicable manual.

QUIZ

1. When the air valve is set to normal oxygen, at sea level, on the 2858 series regulator, a suction not to exceed 1.6 inch of H_2O is sufficient to deliver a flow of
   a. 154 liters diluted oxygen per minute
   b. 150 liters diluted oxygen per minute
   c. 152 liters diluted oxygen per minute
   d. 157 liters diluted oxygen per minute

2. Types 2858–A1, –A1A, –B1, and –C1 of the AN6004–1 regulator series are constructed to operate on an input of
   a. 60 to 1,800 p. s. i.
   b. 15 to 1,800 p. s. i.
   c. 300 to 1,800 p. s. i.
   d. 500 to 1,800 p. s. i.

3. When the A–14 regulator is used in nonpressurized aircraft, the dial is set with reference to flight
   a. schedules
   b. time
   c. altitudes
   d. attitudes

4. The demand valve of a 2858 regulator is located between the
   a. pressure reducer and injector
   b. injector and air valve
   c. inlet valve and pressure reducer chamber
   d. upper demand valve chamber and the injector

5. It is necessary for the 2858 pressure reducer to shut off the flow when the diaphragm is horizontal so
   a. enough pressure can be built up in the chamber
   b. the injector will unseat between 13 and 25 p. s. i.
   c. sufficient volume can be contained in the chamber
   d. the top of the pressure reducer bellows will not hit the relief vent

6. A regulator used above an altitude of 40,000 feet must have a pressure breathing back to
   a. give a continuous flow of oxygen
   b. prevent inboard mask leakage
   c. provide the necessary partial pressure
   d. raise the partial pressure to atmospheric pressure

7. The service ceiling of the 2858 regulator does not exceed
    a. 35,000 feet
    b. 37,000 feet
    c. 40,000 feet
    d. 43,000 feet

8. Regulator models 2862, 2864, 2867, and 2873 are designed for use in aircraft having service ceilings up to
    a. 43,000 feet
    b. 40,000 feet
    c. 37,000 feet
    d. 35,000 feet

9. A pressure gage, mounted on a regulator supplied through a pressure reducer, will not indicate readings in excess of its
    a. pressure gage
    b. calibrated delivery pressure
    c. delivery pressure
    d. cylinder pressure

10. The service ceiling of the 2863 regulator is
    a. 35,000 feet
    b. 37,000 feet
    c. 40,000 feet
    d. 43,000 feet

11. When the safety press is actuated, the outlet pressure should be
    a. 1.75 plus or minus 0.25 inch of water
    b. 1.25 plus or minus 0.25 inch of water
    c. 1.50 plus or minus 0.25 inch of water
    d. 2.00 plus or minus 0.25 inch of water

12. The allowable system leakage on an aircraft equipped with one 514-cubic inch automatic cylinder and one regulator is
    a. 50 p. s. i.
    b. 60 p. s. i.
    c. 90 p. s. i.
    d. 70 p. s. i.

13. When the emergency valve is opened on the 2858–A1 regulator, the
    a. flow indicator will stay open
    b. flow indicator will stay closed
    c. flow indicator will blink
    d. the oxygen flow bypasses the flow indicator

14. When installing a remote oxygen flow indicator
    a. 3/16-inch aluminum tubing is used
    b. 5/16-inch aluminum tubing is used
    c. 1/4-inch aluminum tubing is used
    d. 1/2-inch aluminum tubing is used

15. The latest pressure type regulators are not equipped with a/an
    a. flow indicator
    b. inlet valve
    c. safety press
    d. emergency valve

16. All oxygen regulators must be bench tested if they fail to meet the ground-crew check which occurs every
    a. 90 days or 120 hours
    b. 120 days or 90 hours
    c. 60 days or 100 hours
    d. 90 days or 100 hours

17. When ground-crew checking the 2858 regulator for leakage, with the feeder tube blocked, the flow indicator should not open in less than
    a. 40 seconds
    b. 60 seconds
    c. 20 seconds
    d. 30 seconds

18. The inlet side of an AN6010–1 regulator should never be attached to a supply source greater than
    a. 450 p. s. i.
    b. 500 p. s. i.
    c. 600 p. s. i.
    d. 475 p. s. i.

19. The following regulators have pressure breathing backs:
    a. 2858, 2867
    b. 2867, 2863
    c. 2862, 2867
    d. 2858, 2864

20. The emergency valves have been removed on regulator models 2862, 2863, and
    a. 2858
    b. 2864
    c. 2867
    d. 2872

CHAPTER 3

INSTRUMENTS AND OXYGEN CYLINDERS

This chapter will describe those instruments designed to indicate a positive flow of gaseous oxygen through demand type regulators. It will discuss pressure gages and their use in relation to supply and duration. Pressure reducing regulators, laboratory testing devices, and quantity gages used in liquid oxygen systems represent additional subjects. Oxygen cylinders, sizes, types, and duration factors are treated at length. First, we will consider the oxygen flow indicator.

OXYGEN FLOW INDICATORS

Pioneer Type DJ–2–1

The DJ–2–1 OXYGEN FLOW INDICATOR is a device used with the diluter-demand oxygen regulator (AN6004–1 series) for the purpose of providing a continuous indication of the functioning of the oxygen regulator demand valve. The blinker plate or "eye" of the flow indicator is synchronized with the action of the demand valve of the regulator. Action of the demand valve, in turn, depends on the breathing of the user of the oxygen regulator. For testing purposes, the demand valve can be made to function by breathing through the regulator or by alternately depressing and releasing the diaphragm knob in the center of the face of the regulator. (See fig. 3–1.)

Study figure 3–2 for nomenclature of parts and their relationship in the instrument.

OPERATION.—Oxygen passes directly from the upper demand valve chamber into the flow indicator through a tiny orifice pressed into its outlet. The orifice serves to reduce

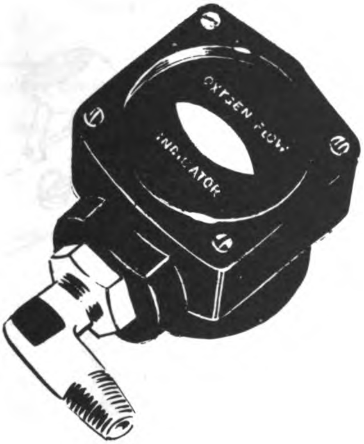


Figure 3–1.—Pioneer type DJ–2–1 oxygen flow indicator.

the working pressure of the regulator to a lower pressure valve which is capable of actuating the lever and plate assembly without rupturing the piston seal. The lever and plate assembly is secured inside the frame and piston seal of the flow indicator. A pressure variance of as little as ½ p. s. i. will operate the indicator and cause it to "blink."

Pressure exerted against the bottom of the piston seal presses the diaphragm plate up. This action, in turn, causes the lever and plate assembly to move back or open so that the black portion of the plate is visible through the face of the indicator. Whenever the black part of the plate is visible, pressure is holding the plate open. When the pressure is released, the lever and plate assembly is returned by spring action to the forward or closed position. This makes the white part of the plate visible through the face of the indicator. (See fig. 3–3.) The lever and plate assembly must open and close completely with each cycle of breathing. Since oxygen bypasses the working parts of the regulator when the emergency valve is used, the flow indicator will not "blink."

Mounting the flow indicator may be either direct or remote. Use a thread sealing and antiseize compound on all pipe

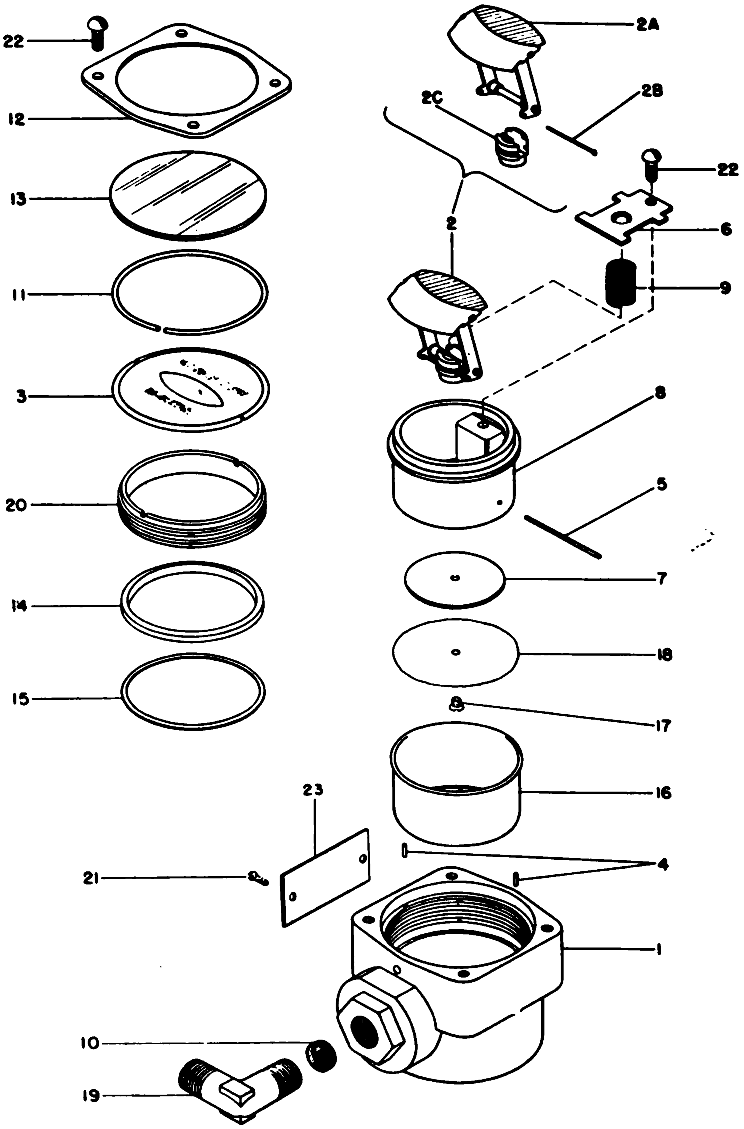


Figure 3-2.—Exploded view.

Nomenclature for figure 3–2

1. Case.
2. Lever assembly.
2A. Lever and plate assembly.
2B. Pin.
2C. Diaphragm hub.
3. Dial.
4. Knob pin.
5. Pin.
6. Plate.
7. Diaphragm plate.
8. Frame.
9. Spring.
10. Screen.
11. Gasket.
12. Bezel.
13. Dial glass.
14. Ring.
15. Packing washer.
16. Piston seal.
17. Screw.
18. Diaphragm shield.
19. Elbow.
20. Retaining ring.
21. Screw.
22. Screw.
23. Nameplate.

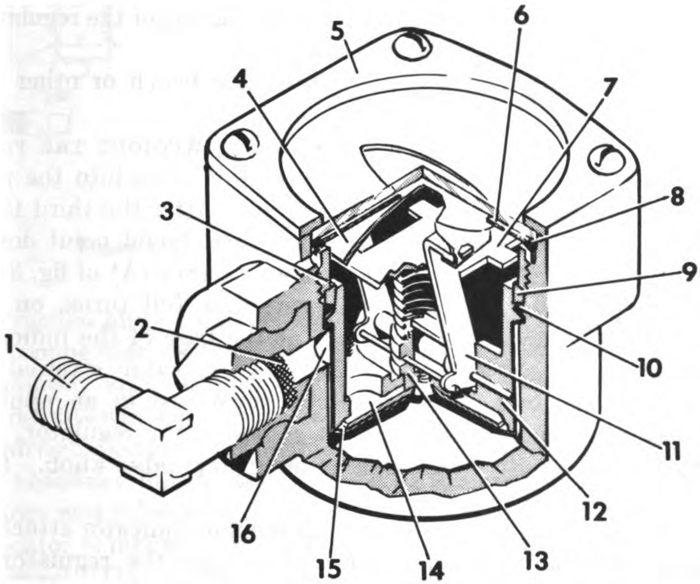


Figure 3–3.—Three-quarter cutaway view.

1. Elbow.
2. Screen.
3. Retaining ring.
4. Blinker plate.
5. Bezel.
6. Dial.
7. Plate.
8. Gasket.
9. Ring.
10. Packing washer.
11. Lever and plate assembly.
12. Frame.
13. Diaphragm hub.
14. Diaphragm plate.
15. Diaphragm shield.
16. Piston seal.

threads and threads of flared aluminum fittings. The compound is always applied EXTERNALLY, never INTERNALLY. Internal or excessive use of the compound can easily result in clogging the line. For pipe fittings, the compound is used only on the external threaded portion of the fittings for sealing and antiseize purposes. In the case of flared aluminum fittings, the compound is used only on the external threaded portion for easy attachment and removal of the fittings.

When mounting the indicator directly on the regulator (AN6004–1 series) do not attempt to screw the 90-degree elbow fitting into the regulator with the flow indicator already attached to the fitting.

Mount as follows:

1. From the pipe thread outlet on the side of the regulator, remove the plug for the flow indicator.
2. Place the regulator, face up, on a bench or other flat surface.
3. Screw the 90-degree elbow fitting, WITHOUT THE FLOW INDICATOR ATTACHED, at least three full turns into the pipe thread outlet of the oxygen regulator. After the third turn, the unattached end of the elbow fitting should point downward toward the base of the regulator. (See (A) of fig. 3–4.)
4. Screw the indicator, at least three full turns, on the elbow fitting. Use the hex nut at the base of the indicator as a wrench grip. With the flow indicator screwed on tightly, the face of the indicator must rest in an approximately vertical plane, at right angles to the regulator, and turned in the direction of the emergency valve knob. (See (B) of fig. 3–4.)
5. Screw the elbow fitting, with the flow indicator attached, approximately another quarter turn into the regulator so that the face of the indicator is now in a horizontal plane parallel to the base of the regulator. (See (C) of fig. 3–4.)

For a remote mounting, mount the flow indicator in accordance with the dimensional drawing of figure 3–5. Remove the plug from the flow indicator outlet on the side of the oxygen regulator. Connect the flow indicator, following specifications as outlined in *Handbooks of Maintenance*

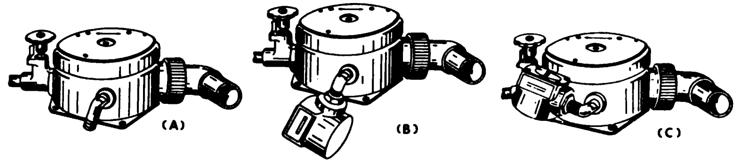


Figure 3–4.—Flow indicator direct mounting steps.

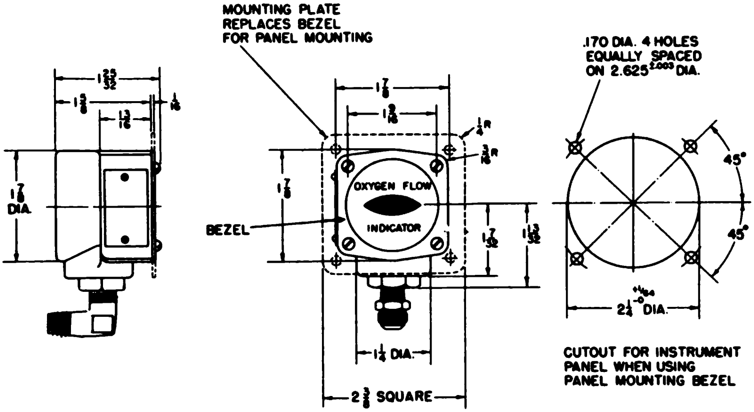

MOUNTING PLATE REPLACES BEZEL FOR PANEL MOUNTING
.170 DIA. 4 HOLES EQUALLY SPACED ON 2.625±.003 DIA.
1 23/32
1 5/8
13/16
1/16
1 7/8 DIA.
1 7/8
1 3/16
1/4 R
3/16 R
OXYGEN FLOW INDICATOR
BEZEL
1 7/8
1 7/32
1 13/32
45°
45°
2¼ +1/64 -0 DIA.
1¼ DIA.
2⅝ SQUARE
CUTOUT FOR INSTRUMENT PANEL WHEN USING PANEL MOUNTING BEZEL

Figure 3–5.—Dimensional drawing of flow indicator.

Instruction and/or *Change Bulletins.* It is possible to make the connection with ⅛-inch or 5/16-inch outside diameter aluminum alloy tubing or 3/16-inch O. D. copper tubing. Proper fittings would have to be employed in order to make an airtight series of connections. Chapter 4 will provide all the necessary information relative to the proper selection of fittings and tubing for specific jobs and examples. When the indicator is mounted on a panel, the mounting plate replaces the bezel. Do not attempt to mount the flow indicator, using ⅛-inch O. D. tubing, more than 10 FEET away from the regulator. More distant mounting will result in sluggish operation or no operation of the indicator. The diameter of tubing used in making the connection determines the distance away from the regulator that a flow indicator can be successfully mounted. In other words, increase the internal diameter (capacity of the tubing) in which the oxygen pressure is contained, and its effectiveness will be weakened to a point where it will no longer be able to actuate anything.

In making an INSTALLATION CHECK, close the emergency valve and turn on the oxygen supply.

Apply a film of soap solution around all flow indicator line connections and joints. The soap solution should be made from water and a pure soap to a consistency of castor oil. When applied, it must be free from bubbles. It must be applied in a clear, continuous film around connections or joints to be tested. Depress the diaphragm knob or breathe through the regulator, and examine the connections and joints for leaks.

Without freezing the threads, tighten any connections or joints at which leaks occur. If necessary, replace any damaged or faulty installation fittings.

With the emergency valve CLOSED and the oxygen supply ON, breathe through the regulator or alternately depress and release the diaphragm knob in the center of the regulator face. (Some types are covered.) Depress at intervals of 2 or 3 seconds, and observe the "eye" of the flow indicator. The "eye" should appear black with the diaphragm knob depressed and white or luminous with the knob in the released position.

If the flow indicator does not function properly, excessive resistance to the flow in the line, in the case of remote mounting, may be responsible. In this event, test to make certain that the line is capable of passing a minimum of 2 liters per minute flow with either a pressure or suction of 2 p. s. i.

INSPECTION AND MAINTENANCE.—The flow indicator is inspected at the same time the regulator is given an inspection. This, of course, can mean every day.

A small vent hole in the case of the flow indicator, which permits an equalization of pressure inside, may be used to test the instrument for leakage. Leakage can be detected by an application of a film of soap over the vent while pressure is being evenly applied. Do not mistake pressure variances for a leak. A soap bubble will pulsate with changing pressures inside the indicator case. A leak will be evidenced by a series of bubbles persistently coming forth from around the area in question. A leaky flow indicator cannot be relied upon, therefore, it must be replaced.

Once the flow indicator is installed, very little maintenance is necessary outside of occasionally changing a broken glass cover or replacing the entire indicator assembly.

Oxygen Flow Indicator Assembly

(Composite)

This flow indicator assembly is principally the same as the one previously described. Instead of a separate case to house the frame and other parts, the indicator assembly is housed in the case of the regulator.

The oxygen flow indicator "blinks" upon the intermittent application of from 5 to 7 inches of water pressure created by the flow of oxygen. The automatic pressure breathing oxygen regulator delivers a pressure of 5 to 7 inches of water to the mask at approximately 41,000 feet, and this pressure is likewise transmitted to the oxygen flow indicator, which will remain open as long as pressure is applied. Accordingly, the flow indicator will not "blink" above this altitude; however, the positive pressure in the mask is an unmistakable indication that oxygen is being delivered to the mask and no apprehension should be felt as long as the flow indicator remains OPEN above 41,000 feet. It is imperative that frequent attention be given to the flow indicator as it is the "sentinel" of the oxygen system.

Since this indicator assembly is installed in the face of the regulator case, it will not be necessary to discuss any direct mounting problems. However, a DJ–2–1 indicator can be remotely connected to any Pioneer composite or pressure type oxygen regulator. Connection is made through an external outlet which leads directly to the regulator's upper demand valve chamber. The outlet is located on the side of the regulator case.

The flow indicator is inspected at the same time as the regulator regardless of whether it is in a composite assembly or remotely mounted. When the flow indicator of a composite type regulator becomes inoperative the entire regulator must be replaced.

Type A-3 (AN6029-1)

This instrument is for use in aircraft oxygen-breathing installations, and serves the same purpose as the other two described. Figure 3-6 illustrates the A-3 indicator, showing front and back views.

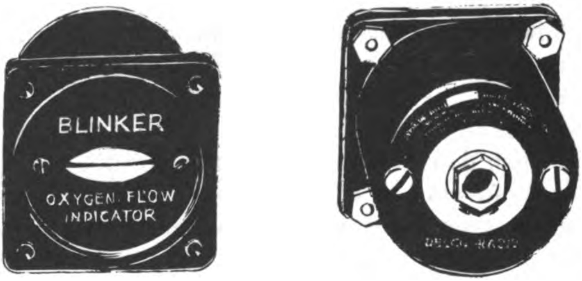


Figure 3-6.—Type A-3.

Operation.—Oxygen under pressure is admitted to the bellows and body assembly through the threaded connection in the rear of the indicator. The pressure of the oxygen causes the flexible metal bellows to move toward the front of the indicator against the pressure of the spring. When the spring pressure equals the applied pressure of the oxygen, the bellows will come to rest at some position between its limits of travel, the position depending entirely upon the oxygen pressure.

At each inspiration of the person wearing the mask (connected to an oxygen demand regulator to which this indicator is connected), the pressure in the bellows chamber changes approximately ½ p. s. i. This causes the bellows to assume a new position. When the oxygen pressure returns to its original value, the bellows will assume the position previous to the ½-p. s. i. change.

Any movement of the bellows causes a corresponding movement of the push rod as the button on the rod is held in constant contact with the bellows by the spring washer.

As the push rod moves back and forth, it operates the shutters by means of a friction clutch. The friction clutch is composed of two pieces: a clutch and a friction clip. The clutch is assembled on the push rod and is held in contact with the push rod by the friction clip. This replaces the friction clutch as used on earlier models, composed of 3 parts: a clip, an insert, and a clutch.

The largest diameter of the clutch contains a circular groove which engages the shutter pins of the shutter assemblies, which swing about pivot points. The limit of travel of the shutters is fixed by stops. The amount of movement of the clutch, necessary to operate the shutters through their full travel, is approximately 1/64 inch while the total travel of the bellows and push rod can be approximately 3/8 inch. The clutch permits the bellows to move any amount in excess of the 1/64 inch necessary to operate the shutters by allowing the push rod to slip through. The clutch will slip under any pressure in excess of 3 ounces.

Inspection and maintenance.—This item as any other oxygen unit must NEVER be tested or operated with compressed air which contains the slightest trace of oil, grease, moisture, or any other foreign matter, or oxygen containing a trace of moisture or any foreign matter.

Conduct regular inspections in accordance with latest directives; however, a special inspection may be conducted after the indicator has been disconnected from the line as follows:

First, check the operation of the shutters by inserting the eraser end of a pencil through the large threaded hole in the back of the indicator, and press gently against the bellows and release. Failure of the shutters to open and close would indicate a weak or broken spring, or defective shutter assembly.

Second, check the bellows and body assembly, connect the indicator to an oxygen supply source, raise pressure in the indicator to 10 p. s. i., and close off supply. If at the end of 5 minutes the shutters have not begun to close, the bellows and body assembly do not leak.

No lubricant is needed in the mechanism or interior parts. FAILURE TO OBSERVE THESE INSTRUCTIONS MIGHT RESULT IN AN EXPLOSION.

PRESSURE REDUCING REGULATORS

Pressure reducing regulators are designed to receive oxygen gas from a high pressure source, and to deliver the oxygen at a constant reduced working pressure. An oxygen pressure reducer used in an aircraft system is preset at the factory to deliver a specified outlet pressure. This adjustment is sealed to prevent an accidental change in pressure. Pressure reducers used on recharge carts and other similar pieces of equipment are basically used for the same purpose as the preset types installed in aircraft oxygen systems; they all reduce the source of pressure. However, a cart-type pressure reducing regulator (used for cascading oxygen) must be easily adjusted in order to deliver different pressures for servicing different systems. This adjustment is accomplished by screwing an external handle in or out on the front of the instrument. Do not confuse the oxygen pressure reducing regulator with the diluter-demand, demand, or continuous flow type oxygen regulators. The pressure reducing regulator is designed for one purpose only—reducing pressure.

OPERATION.—The preset type pressure reducer used in aircraft systems operates on simplified principles. Incoming oxygen under a pressure of 1,800 p. s. i. or less (1,800 p. s. i.–65 p. s. i.) enters the working pressure chamber through the stem (1), when the pressure in the chamber is slightly less than 60 p. s. i. A projector (2), attached to a flexible diaphragm is spring-pressed in contact with a spring-operated valve plunger (3), located in the stem. When pressure builds up in the working chamber to the adjusted valve, the diaphragm flexes away from the nozzle (4), drawing the projector (2), with it. This causes the valve plunger (3), which is always in contact with the projector, to follow it and close off the valve seat (5). No more oxygen will enter the working chamber until outlet (6) is opened somewhere in the system, as a result of breathing. Every inhalation

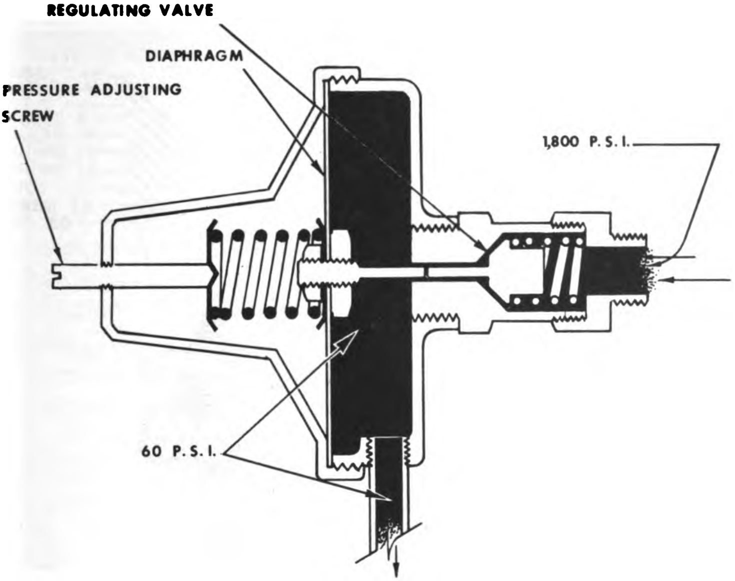


Figure 3–7.—Simplified drawing of the preset type pressure reducer.

and exhalation action through a diluter-demand breathing regulator, connected downstream, will cause the diaphragm in the pressure reducing regulator to react with the valve plunger. In a continuous flow operation, the parts assume an equilibrium so that oxygen is admitted exactly as required to equal the outgoing flow and maintain the desired working pressure.

In other words, the flow might be continuous or intermittent as the spring-loaded diaphragm reacts to changes in the oxygen pressure exactly in proportion to the countering adjusted-spring pressure. Back off the spring pressure on the diaphragm, and a greater oxygen working pressure will result. (See fig. 3–7.)

Harris Calorific Reducer

(Models 41 and 41–A)

These regulators are of the so-called "direct action" type. The working pressure does not diminish as the oxygen in the storage cylinder is used, but a slight increase is noted. This

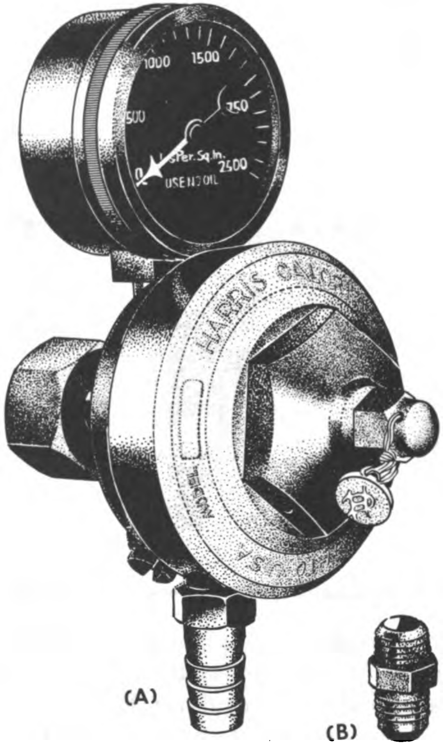


Figure 3–8.—(A) Model 41 pressure reducing regulator; (B) nipple for model 41–A pressure reducing regulator.

is of importance in maintaining full working pressure until the storage or supply cylinder nears exhaustion.

Models 41 and 41–A are illustrated in figure 3–8.

Sectional and exploded views are shown in figures 3–9 and 3–10. Each part or subassembly has been assigned a reference number. Model 41 is set to deliver oxygen gas at a pressure of approximately 12 p. s. i. and is provided with an outlet connection for rubber tubing. Model 41–A is set to deliver oxygen at a pressure of approximately 60 p. s. i. and is provided with an outlet connection for ⅜-inch metal tubing. Both models are arranged for mounting on high-pressure oxygen cylinders and are designed to receive

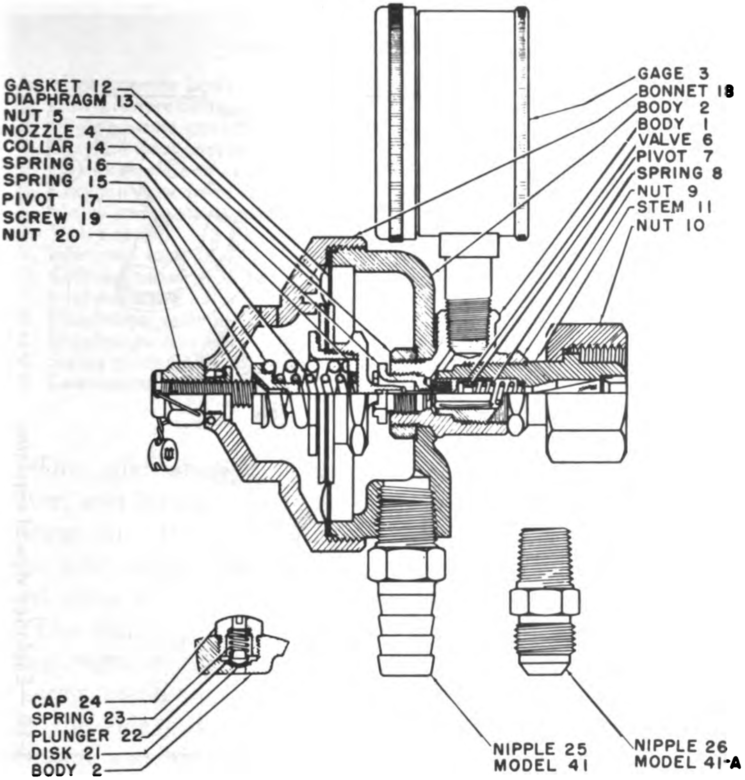


Figure 3–9.—Sectional view of regulator.

oxygen gas at any pressure up to an including 2,000 p. s. i. The working pressure is sealed at the factory, and any readjustment of the working pressures requires breaking a seal. This is to be accomplished by authorized personnel of an Overhaul and Repair Shop. DO NOT ATTEMPT TO ADJUST THE OUTLET PRESSURE IN THE FIELD.

CONSTRUCTION (fig. 3–10).—The body (1) is a cadmium-plated brass forging into which the high-pressure indicating gage (3), the nozzle (4), and the inlet stem assembly (11) are screwed. The body (2), retaining the outlet nipple (25) for model 41 (or nipple (26) for model 41–A), seats against body (1) and is held in place by a nut (5).

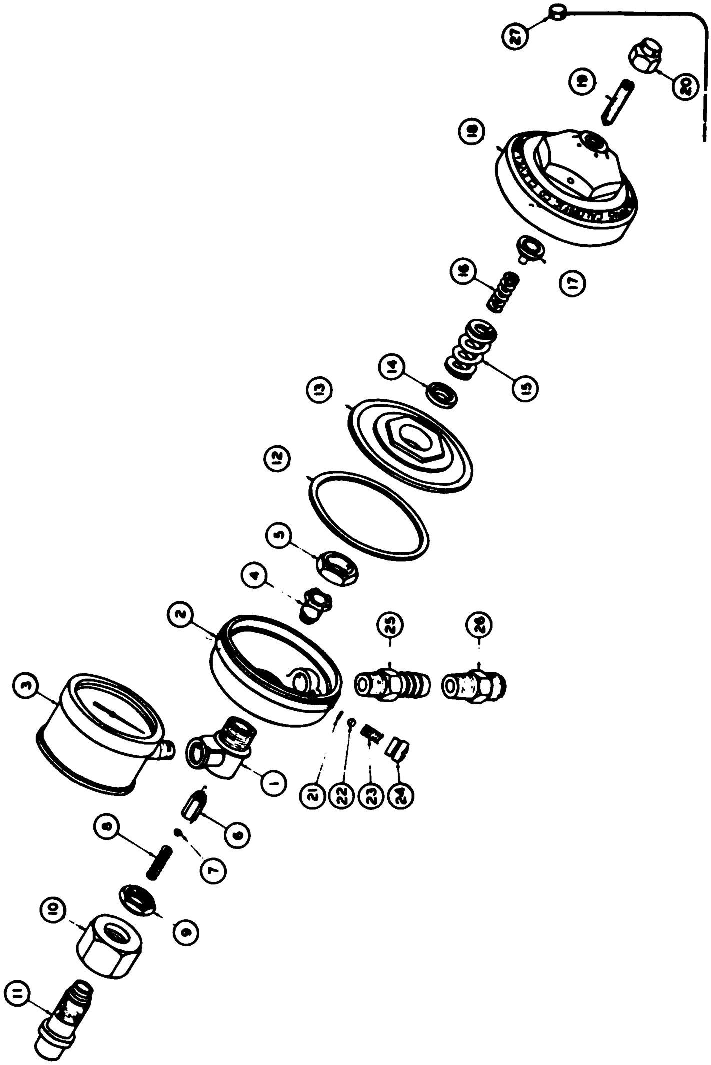


Figure 3–10.—Exploded view of regulator.

Nomenclature for figure 3–10

1. High-pressure body.
2. Low-pressure body.
3. High-pressure gage.
4. Oxygen flow nozzle.
5. Low-pressure body retaining nut.
6. Oxygen flow valve assembly.
7. Valve spring thrust pivot.
8. Valve spring.
9. Inlet stem locknut.
10. Cylinder connection nut.
11. Inlet stem assembly.
12. Diaphragm gasket.
13. Diaphragm assembly.
14. Spring guide collar.
15. Low-pressure spring.
16. High-pressure spring.
17. Pivot assembly.
18. Bonnet assembly.
19. Pressure adjusting screw.
20. Adjusting screw locknut.
21. Relief valve seat disk.
22. Relief valve spring plunger.
23. Relief valve spring.
24. Relief valve cap.
25. Outlet nipple for low-pressure setting of approximately 12 p. s. i.
26. Outlet nipple for higher low-pressure setting of approximately 60 p. s. i.
27. Lead seal for sealing wire.

The inlet stem assembly (11) contains a wire screen filter, and houses the valve assembly (6), a pivot (7), and spring (8). It is secured to the body (1) by a locknut (9). The inlet connection nut (10) screws onto the cylinder valve and seats the stem assembly in the recess of the valve.

The diaphragm assembly (13) consists of a flexible metal diaphragm with a backing disk on either side to support it, a screw, and a nut into which is pressed a plunger contact pin. On the side opposite the contact plunger pin of the diaphragm assembly is inserted the spring guide collar (14). The bonnet (18) screws onto the body (2) and seals the diaphragm assembly against it with a gasket (12). It contains a bushing in which the adjusting screw turns, exerting its thrust against the pivot assembly (17), which compresses springs (15) and (16). A nut (20) locks the adjusting screw setting. A wire seal prevents anyone from tampering with the adjustment.

The safety assembly located in the body (2) consists of a rubber disk (21), plunger (22), spring (23), and cap (24).

Installation of the regulator is simply effected by tightening the nut (10) on the threads of the oxygen cylinder valve. The inlet stem (11) seats in the recess in the cylinder valve. Before making an installation, make sure that no dirt or grease is present on the end of the inlet stem (11) or in the oxygen cylinder valve. Always open the cylinder valve for a fraction of a second to blow out any foreign material before installing a regulator. Such foreign material may not only cause improper functioning of the regulator, but may be a serious explosion hazard.

OPERATION.—The principles of operation will be more easily understood by referring to figure 3–9. The regulator is attached to the oxygen cylinder valve by a nut (10). Incoming oxygen passes through the stem (11). Any foreign material present is stopped by a fine screen in the stem. Passage of oxygen into the working pressure chamber of the body (2) is prevented by the valve (6) being closed against the nozzle (4) by a spring (8). Spring pressure is centralized by the pivot (7).

Working pressure chamber in the body is closed on one side by the flexible diaphragm assembly (13). By rotating the adjusting screw (19), two springs (one (15) for pressures above 15 p. s. i. and the other (16) for lower pressures) are compressed, and the diaphragm assembly (13) is caused to flex until a projection the diaphragm assembly makes contact with the plunger of the valve (6). This causes unseating of the valve and flow of oxygen into the working pressure chamber. If the outlet is closed, oxygen pressure builds up against the diaphragm until spring pressure is overcome, and the valve (6) reseats against the nozzle (4).

As spring pressure is increased by further turning of the adjusting screw, it will be seen that more gas will enter the working pressure chamber. Thus, any desired working pressure within the range of the regulator may be established at will by increasing or decreasing the spring pressure.

If the outlet is opened, oxygen will escape from the working pressure chamber, the spring pressure will overcome the oxygen pressure within, the valve (6) will become unseated, and oxygen will flow into the working pressure chamber to replace the outgoing flow. In operation, the parts assume an equilibrium so that oxygen is admitted exactly as required to equal the outgoing flow and to maintain the desired working pressure.

Other factors being equal, the working pressure will assume a value slightly below that established with the outlet closed, the exact value depending upon the rate at which the oxygen is discharged.

The pressure of the oxygen in the cylinder is indicated on a gage (3). This pressure is an index as to the quantity of oxygen in the cylinder.

After installation of the regulator, its operation is entirely automatic, and no further manual adjustment is required.

MAINTENANCE.—One of the details necessary in performing maintenance on this equipment is the establishment of a SERVICE INSPECTION.

Absence of wearing parts in the regulator precludes establishment of definite time intervals for replacement of worn parts. The action of the regulator may be affected due to certain impurities or foreign material entering the regulator in the oxygen stream, corrosion of the interior of oxygen cylinders, and wear of moving parts of oxygen cylinders. Inspect the regulator at regular intervals for correct operating characteristics. Inspect for external leaks, and determine that the reading of the pressure gage is accurate if the regulator has been subjected to extreme shock or concussion. This instrument may be inspected at the same time diluter-demand breathing regulators are given the "bench check."

Regulators failing to pass a periodic inspection must be replaced by properly working instruments. Return defective units for overhaul.

Caution: Before conducting a STATIC PRESSURE TEST, be sure that the operator's hands and all tools are absolutely free from oil, grease, or dirt. The slightest trace of oil, grease, or other foreign substances containing hydrocarbons in the high-pressure system of an oxygen regulator may result in a violent and destructive explosion when oxygen gas is admitted. The importance of this precaution cannot be overemphasized. Always open the cyliner valve for a fraction of a second to blow out any foreign material lodged in the valve before mounting the regulator on any oxygen cylinder.

To conduct a STATIC PRESSURE TEST proceed as follows:

Mount the regulator on an oxygen storage or supply cylinder containing at least 1,800 p. s. i.

Fasten the flow testing fixture to the outlet of the regulator (figs. 3–11 and 3–12) by tightening the hose clamp (B) on model 41 regulators or by tightening union connection (A) on model 41–A regulators. When testing model 41 regulators, open valve (E), and close valve (D). When testing model 41–A regulators, open valve (D), and close valve (E). Outlet valve (F), opposite gage (C) is fitted with a plug (G) in which a No. 56 (0.0465 inch) orifice is drilled. NEVER REMOVE PLUG (G).

Open outlet valve (F). Open the valve on the oxygen cylinder fully. Close the outlet valve (F.) Observe the gage (C). The pressure should remain constant at a point between 11 p. s. i. and 13 p. s. i. in the case of model 41 regulators, and at a point between 60 p. s. i. and 62 p. s. i. in the case of model 41–A regulators.

To check for EXTERNAL LEAKAGE, apply a soap solution to all joints and the exterior of the regulator. Bubbles are evidence of external leakage which is wasteful of oxygen, a definite hazard, and which may conceal defects in operating characteristics of the pressure reducer. Leaks should be corrected by replacing the instrument with a new one.

In the FLOW PRESSURE TEST, if no external leaks are in evidence and the pressure indicated on the gage (C) of the flow testing fixture becomes static (does not fluctuate beyond limits—within the limits specified between 11 p. s. i. and 13 p. s. i. for model 41, and 60 p. s. i. and 62 p. s. i. for model 41–A), open the outlet valve (F) of the flow testing fixture, and observe the indication of the gage (C) on the flow testing fixture. The pressure should not fall below an indicated gage pressure of 9 p. s. i. in the case of the model 41 regulator, nor below an indicated gage pressure of 54 p. s. i. in the case of the model 41–A regulator. In other words, the flow pressure should not be more than 3 p. s. i. less than the static pressure previously registered on the gage for the model 41 and not more than 6 p. s. i. less than the static pressure for the model 41–A. It is possible for the regulators to operate properly, controlling the fluctuating

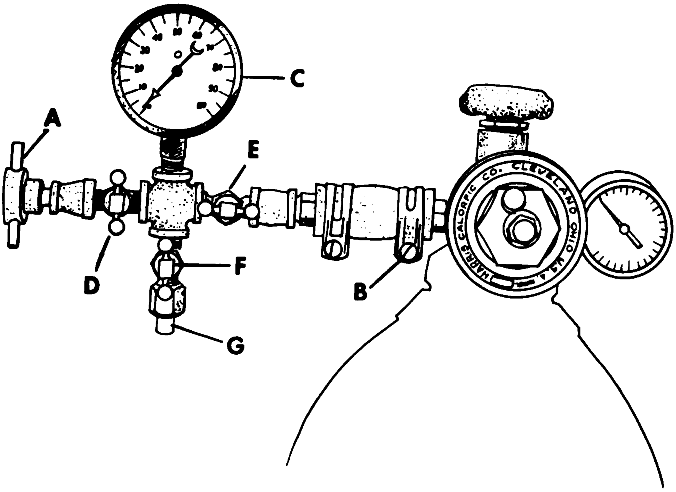


Figure 3–11.—Flow testing fixture applied to model 41 regulator.

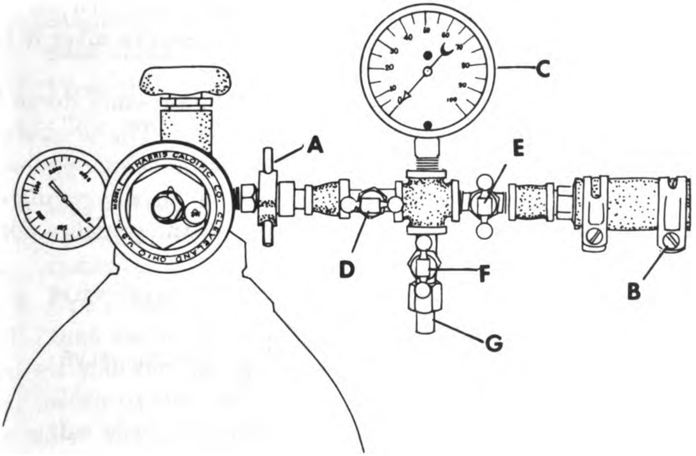


Figure 3–12.—Flow testing fixture applied to model 41–A regulator.

flow pressure within the prescribed values, but at the same time permitting proportionately greater or lesser static gage pressure readings. When this happens, the condition can be corrected by readjusting the pressure settings of the applicable regulators.

The pressure gage used for the static and flow pressure tests must be accurate. Compare its readings with a master gage of known calibration applied to the oxygen cylinder used for testing.

No lubrication is required. When specifications for other oxygen equipment require a lubricant, be absolutely certain it is used as directed. Remember, lubricants containing a hydrocarbon base or vehicle are potential dynamite around oxygen equipment.

Balanced Pressure Regulator

This type pressure reducing regulator is used on some types of oxygen recharge carts. (See fig. 3–13.) The master pressure gage is located downstream of the regulator's outlet pressure, indicating the reduced pressure in comparison with the supply source. Each source of supply (high-pressure storage cylinder) is fitted with its own pressure gage, offering a comparison of different pressures between the pressure entering the regulator and the pressure after it has left the regulator.

The pressure is allowed to flow into the pressure dome by means of two hand-operated needle valves. The pressure is usually common with the pressure that is being regulated and is taken off near the IN connection on the regulator. The desired amount of pressure is fed into the pressure dome

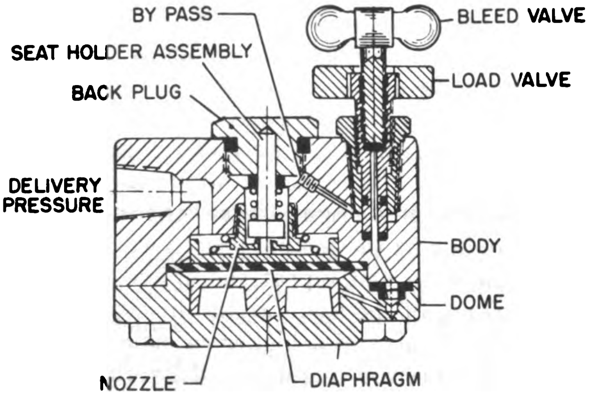


Figure 3–13.—Balanced pressure regulator.

and trapped by means of a load valve. The bleed valve is then closed to shut off the connection between the IN and the pressure dome. The bleed valve is used when lowering the regulator setting. The regulator setting can be lowered by opening the bleed valve which decreases the pressure and allows part or all of this pressure to bleed out through the valve stem. The rest of the regulator works the same as a spring-loaded type; that is, when the pressure is loaded into the dome, it exerts a force on the diaphragm which opens the check valve and allows the gas to flow through the check and out the regulator. This gas flows past the lower side of the diaphragm and when it reaches the predetermined pressure, it opposes the set pressure in the dome and allows the regulator check to close.

OPERATING INSTRUCTIONS.—Always use the pressure reducing regulator when cascading oxygen as follows:

1. The bypass valve located between the upper and lower manifolds should always be closed tightly. The bypass valve is installed for emergency use only.
2. Close line valve on hose.
3. Close valves on regulator.
4. Open load valve on regulator approximately ½ a turn.
5. Open very slowly the control valve of the cascade cylinder. This should be a higher pressure than the indicated pressure in the aircraft system.
6. Open carefully the bleed valve on the regulator so that gas flows through the regulator until the gage on the lower manifold reads the desired pressure, then close quickly the load valve on the regulator. Close the bleed valve. It is normal for gas to leak out of the valves on the regulator when open.
7. If pressure gets higher than the desired delivering pressure during the setting procedure, bleed all pressure from the hose and repeat the above procedure.
8. By blowing off pressure at the line valve and opening the control valve of a higher cascade cylinder pressure than the desired regulator delivering pressure, the setting of the regulator can be checked. Determine

if the correct pressure is taken on the lower manifold pressure gage.

When operating any pressure reducer, always admit pressure very slowly. Never permit a sudden surge of pressure through any system. Open valves slowly!

MAINTENANCE.—Only qualified personnel are authorized to overhaul this equipment, and it is usually performed by Overhaul and Repair Departments. Exercise a sound policy of preventive maintenance by protecting the regulator from harmful practices and elements.

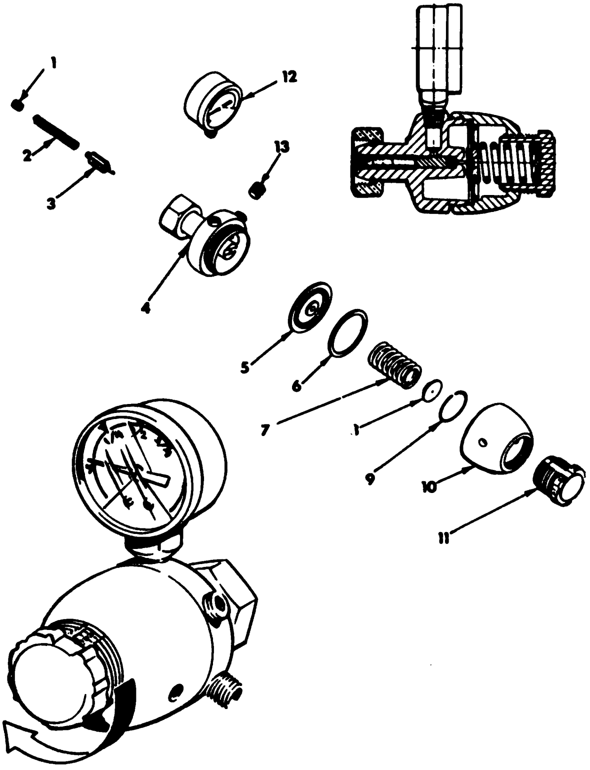
Acetylene Pressure Reducing Regulator

The Prest-O-Lite 411B regulator is a sturdy piece of equipment especially designed for use with Prest-O-Lite small-tank appliances. The regulator eliminates the need for continual readjustment of the tank valve as pressure in the tank drops. When it has been set to the desired working pressure, it will maintain that pressure without any further attention. In shifting the regulator from one tank to another, it is not necessary to change the pressure setting. The regulator is easily installed and is simple to operate.

CONSTRUCTION.—Figure 3–14 illustrates an exploded view of the acetylene pressure reducing regulator. "Prest–O–Lite" is a registered trade-mark of the Linde Air Products Company, a division of the Union Carbide and Carbon Corporation. The principles of operation for this regulator are the same as those applying to the Harris 41 series. However, the Prest-O-Lite 411B regulator offers an adjustable range of pressure settings, a feature not necessary in the Harris 41 regulators.

OPERATING INSTRUCTIONS.—Working pressure is adjusted by use of the red plastic pressure-adjusting screw. To increase pressure, turn the pressure-adjusting screw clockwise. To decrease pressure, turn the screw counterclockwise.

The pressure-adjusting screw has two flat bottom grooves on which the lettered settings, *A*, *B*, *C*, and *D*, are marked at intervals of two turns. These settings serve the same purpose as a working-pressure gage. Letter *A* represents the point at which pressure begins to flow. Letter *B* represents an



Turn clockwise to increase pressure

Figure 3–14.—Exploded view. Acetylene pressure reducing regulator.

1. **Screw.**
2. **Spring.**
3. **Valve seat and guide assembly.**
4. **Body inlet and connecting assembly.**
5. **Diaphragm.**
6. **Ring.**
7. **Spring.**
8. **Washer.**
9. **Ring.**
10. **Caps.**
11. **Pressure adjustment screw.**
12. **Gage.**
13. **Plug.**

approximate working-pressure setting of 5 p. s. i. Letters *C* and *D* represent approximate settings of 10 and 15 p. s. i.

Since the distance from one lettered setting to the next is two full turns (approximately 5 lbs.), pressure settings between the letters are easy to determine. A full turn past

B would give a setting of approximately 7½ p. s. i. A half turn past *C* would give a setting of approximately 11¼ p. s. i.

When the desired working pressure is obtained for a particular operation, the adjusting screw may be left in the position as long as it is being used on the same appliance. If an adjustment becomes necessary because of small changes in operating conditions, it may be made by a slight turn of the pressure-adjusting screw. If desired, a working-pressure gage may be installed in the regulator in place of the ⅛-inch pipe plug.

If the regulator is to be out of use for an appreciable amount of time, leave the pressure-adjusting screw turned in enough to move the valve seat off the seating surface of the body. A quarter turn beyond the *A* setting is generally sufficient.

MAINTENANCE.—Whenever repairs are necessary, return the regulator through supply channels to an authorized Overhaul and Repair Department or to the manufacturer. Keep the regulator clean and free from dusty and dirty areas.

PRESSURE GAGES

A variety of aircraft instruments are operated by FLUID PRESSURE, the pressure being expressed in INCHES OF MERCURY. Fluids are substances which may be made to flow or change their shapes by the application of moderate pressures. In this respect, any gas such as oxygen, a component of air, is considered fluid. Internal friction in most fluids is very small; in some fluids, for ordinary calculations, it may be neglected.

If a surface is immersed in a stationary fluid, the pressure of the fluid will be at right angles to the stationary surface. Some interesting things happen when a fluid is confined in a leakproof container. Under such conditions, an increase in pressure on any part of the confined fluid will cause the same increase in pressure throughout. This is known as Pascal's principle. It does not matter what shape the container, or what kind of a fluid is in it, as long as there are no holes or exits through which the fluid can escape and relieve the pressure.

Pressure gages are connected into the particular systems for which they are designed by means of small pipelines. Each gage actually becomes a part of the "fluid container" of its system, and is supplied with a small quantity of fluid at the uniform system pressure.

The **Bourdon tube** in an oxygen pressure gage is made of metal tubing, oval or somewhat flattened in cross sections, closed at one end and mounted rigidly in the instrument case at its other end. (See fig. 3–15.) Notice that the Bourdon tube is curved like a crescent moon. The compressed oxygen on which it is desired to get a pressure reading is introduced into the fixed end of the Bourdon tube by a small tube leading from the oxygen system to the instrument. The greater the inside oxygen pressure, the more the Bourdon tube tends to straighten out. When the inside pressure drops, the natural springiness of the metal tube's walls make it curve back into its normal shape.

By connecting an indicator needle or pointer to the free end of the Bourdon tube, one can observe its reactions to

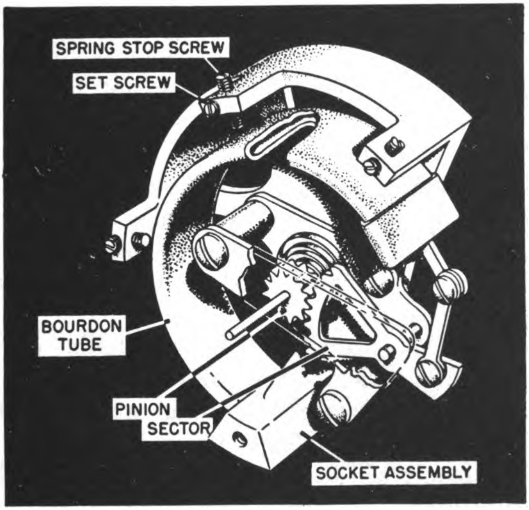


Figure 3–15.—Diagram of Bourdon tube pressure gage.

changes in oxygen system pressure. By placing a properly marked or "calibrated" dial behind the indicator needle, we have a pressure gage that reads in pressure units.

An instrument designed to measure large changes in high-pressure oxygen systems will need a stiff, heavy-walled Bourdon tube. For measuring slight changes in relatively low-pressure systems, the instrument must have a more flexible and sensitive Bourdon tube.

Oxygen pressure gages are required in all aircraft oxygen systems. They show the pressure at which the oxygen is being delivered to the regulator. The measurement indicates to flight personnel the remaining volume of gas in the supply cylinder or cylinders by way of a pressure reading in pounds per square inch. A 514-cubic inch aircraft oxygen supply cylinder will contain approximately 38.40 cubic feet of gas when the gas is compressed to a pressure of 1,800 p. s. i. Thus, as the pressure drops it can be understood how the pressure gage serves as an indicator for the volume of gas remaining in the source of supply.

In a reduced high-pressure system installed in P2V-6 aircraft, a low-pressure oxygen pressure gage is installed downstream of the reduced pressure side of the system and indicates the efficiency of the pressure reducing regulator. So long as a pressure of approximately 65 p. s. i. is maintained, flight personnel know the supply has not been expended, and that the pressure reducing regulator is operating efficiently.

There are operating safety limits relative to the duration of the oxygen supply, and a pressure gage installed upstream between the regulators (breathing types and/or pressure reducing types) is designed to show when these limits are being approached.

SUMMARY.—There are literally hundreds of different kinds of pressure gages, but they all do the same thing, they indicate pressure. Before installing an aircraft oxygen pressure gage determine its capacity in conjunction with the system pressures it will be required to indicate. The gage's location in the line is another thing to keep in mind when working around a reduced high-pressure system. A low-pressure gage installed upstream of a reducer will be ruined. A high-pressure gage installed downstream of a reducer will not be ruined, but its dial graduations are not calibrated fine enough to be read easily. No special lubricants are used in a pressure gage as they would only cause sluggishness of operation during cold weather.

High-Pressure Gages

The high-pressure oxygen system gage (PC–52U36–1) designed with a 1⅝-inch round dial is calibrated to indicate pressure from 0 to 2,000 p. s. i. This gage is used in aircraft oxygen systems. Wherever possible, nonferrous materials are used in its manufacture to preclude the possibility of magnetic disturbances which could tend to give erroneous pressure readings. The indicating and pressure elements comprise a unit distinct from the case, and this unit is sufficiently rugged in construction so that small distortions of the case will not affect the accuracy of the indications. The gage is constructed so that parts will not work loose in service, and it is built to withstand the strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and service use in the aircraft. The case is raintight except for a vent hole on the underside.

The dial is graduated as indicated in figure 3–16. Lumi-

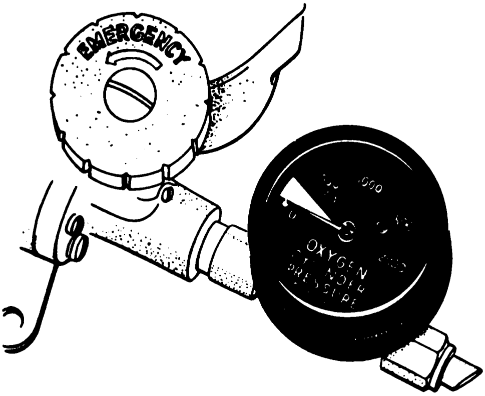


Figure 3–16.—Round dial, 1⅝-inch high-pressure oxygen system gage.

nescent markings eliminate the need for lighting the dial electrically. A warning sector, from 0 to 300 p. s. i., is finished in a fluorescent material, indicating the OPERATIONAL EMPTY limits of the high-pressure oxygen system.

INSTALLATION.—The round dial, 1⅝-inch high-pressure oxygen gage, is mounted on or in high-pressure diluter-demand type regulators. In addition they also may be mounted on aircraft instrument panels or consoles, the location depending on how easily they can be observed by the personnel using them.

MAINTENANCE.—A defective gage is easily replaced on most AN6004–1 model regulators. Simply unscrew it from its T mounting. Before installing a new gage, always check its zero indication and operation by comparing it with a reading from a gage of known calibration.

Prior to joining any threaded member of an oxygen plumbing system, always apply an approved antiseize compound.

Rectoseal No. 15 or its equivalent is a safe and authorized antiseize compound which when applied to the male threads of a pressure gage's pipe projections will help prevent the fixture from "freezing." Apply antiseize compound sparingly on only three or four of the member's outer threads, never letting it smear into openings where it can be carried in the system to eventually clog minute filter screens and tiny orifices. Before using a container of antiseize compound observe its label, look for the boldface print which will read, **FOR USE IN OXYGEN SYSTEMS**.

Do not make adjustments inside the gage as this task is the responsibility of qualified personnel. The cover glass may be replaced if scratched or broken, and the dial pointer may be bent only slightly to aline it accurately with its zero position. After bending the pointer, check the gage with one of a known calibration. Never bend the dial pointer when the system pressure is on. Always shut off or disconnect the supply source, first. A loose fitting dial pointer will give erroneous readings. When this condition is discovered, replace the entire gage.

Composite breathing regulators, being more compact than the AN6004-1 models, must be partly disassembled before the pressure gage can be removed. Because of this, the entire regulator will have to be replaced when its pressure gage becomes defective.

Low-Pressure Gages

The AN6021 pressure gage operates on the same principles as described for the high-pressure gage, but is different in appearance. Figure 3-17 illustrates the external features of this gage. Notice the warning segment is marked between 0 and 100 p. s. i.

The low-pressure gage is usually mounted on the same panel with the flow indicator. The gage shows the oxygen pressure in the cylinder or cylinders that supply a particular station. Normally the pressures in all cylinders will be the same; but if one cylinder in punctured, the check valves will isolate that cylinder and will leave the pressure gage reading practically the same as before, although the oxygen supply will be greatly reduced.

To make intelligent use of any oxygen pressure gage (high

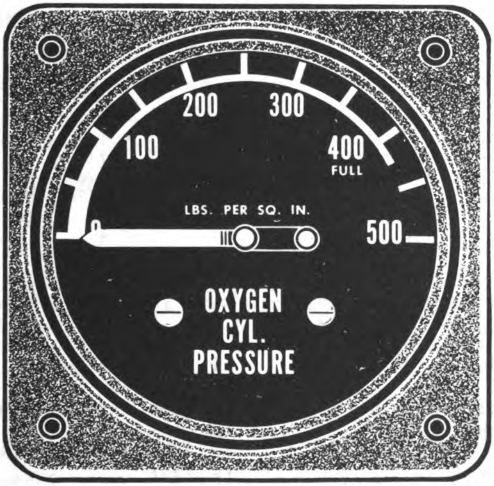


Figure 3-17.—Low-pressure type gage.

or low pressure), one must be familiar with the duration characteristics of a particular aircraft's system.

When a low-pressure oxygen gage becomes damaged, replace it with a new one. The gage is connected to the system by a 5/16-inch tube connection, and is mounted in a panel with four machine screws.

Low-pressure gages, similar in design to the 1⅝-inch high-pressure gage, are illustrated in figure 3–18. Study the illustration for nomenclature and relationship of the parts.

The AW–1–½ gage designed to indicate pressures from 0 to 100 p. s. i. can be installed in reduced high-pressure systems downstream of the pressure reducing regulator. In this location, it can monitor the delivery pressure of the

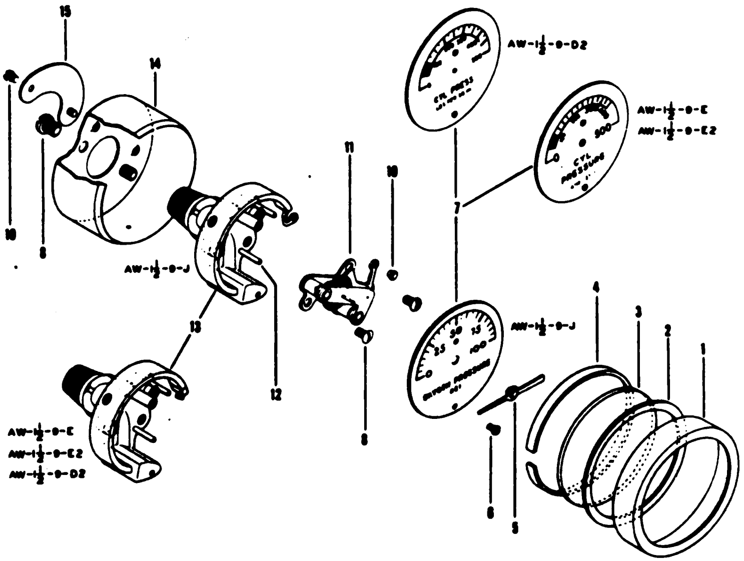


Figure 3–18.—Low-pressure gage—exploded view. Models AW–1–½–9–D2, AW–1–½–9E, AW–1–½–9E2, and AW–1–½–9–J.

1. Friction ring.
2. Gasket.
3. Plain glass.
4. Glassholder.
5. Pointer.
6. Dial screw.
7. Dial.
8. Socket screw.
9. Movement screw.
10. Link rivet.
11. Movement assembly.
12. Stop.
13. Tube-tip assembly socket.
14. Case.
15. Nameplate.
16. Nameplate screw.

reducing regulator. This type gage is easily installed in a line by means of a T connection or some other suitable fitting. One important thing to remember about installing gages is to mount them in a conspicuous location.

QUANTITY GAGE

Oxygen systems having a liquid oxygen supply have a quantity gage installed at the pilot's, copilot's, or flight engineer's station. A quantity gage is installed for each separate converter in the aircraft. It shows the quantity of liquid oxygen in LITERS. A LITER is a unit of CAPACITY in the metric system, and is equal to 1 cubic decimeter or 0.9081 dry quart or 1.0567 liquid quarts. In oxygen systems having a liquid oxygen supply, the pressure in the system is constant until the liquid oxygen is depleted.

CYLINDERS

HIGH-PRESSURE OXYGEN STORAGE CYLINDER.—High-pressure cylinders are made from steel having the characteristics specified in Interstate Commerce Commission Specification 3A–1800. They are manufactured from pierced billets, cupped plates, or seamless tubing with spun bottoms. They are all cylindrical in shape with hemispherical top and an indented bottom. Later model storage cylinders capable of withstanding greater internal pressures are manufactured under a revised ICC, 3A–1800, specification.

Storage cylinders are not used in aircraft oxygen systems. They are used to replenish the oxygen supply of these systems. Storage cylinders, sometimes called supply cylinders, but NOT aircraft supply cylinders, provide permanent and portable type oxygen transfer apparatus with sufficient quantities (cubic footage) of gas to refill innumerable smaller aircraft cylinders.

Interesting facts about the storage cylinder are as follows:

1. DIMENSIONS. 9 inches by 51 inches. Designed to stand on end.

2. Capacity. 200 cubic feet. May be filled to 10 percent over capacity at 70° F.

3. Construction.--Cylinders are made shatterproof by heat treating the steel. They are made of high grade, heavy gage, corrosion resistant steel. Cylinders are fitted with a diaphragm type discharge valve which is protected by a cap or crown. They are seamless in construction.

4. Painting and marking.—Cylinders are painted light green in accordance with established color code. White stripes located diametrically opposite each other are painted along the length of each cylinder to identify them as being shatterproof. Other identification styles direct the painting of a white band around each cylinder to indicate the same characteristic. The name of the gas, AVIATOR'S BREATHING OXYGEN, and the word NONSHATTERABLE or NONSHAT also appear on diametrically opposite sides of the cylinder. The Military Standard Color Code for compressed gas cylinders and pipelines directs a simpler identification. In accordance with this code the oxygen cylinder is painted green with a white band at the top, and the words OXYGEN aviator's appear on diametrically opposite sides as shown in (A) of figure 3–19.

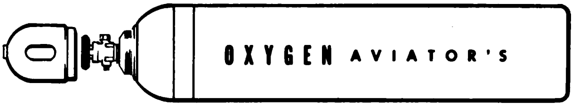


Figure 3–19.—AVIATOR'S BREATHING OXYGEN Storage Cylinder. Cylinder painted in accordance with the Military Standard Color Code.

5. Indented or stamped on the shoulder of each cylinder are certain additional bits of information necessary to its identification. The stamping contains the following information: Name or trade-mark of the manufacturer; the ICC 3A–1800 or ICC 3AA–2265 for 250-cubic foot cylinders; the Navy serial number such as USN–123456–USN; the last hydrostatic test date; and the mark of the ICC accredited inspecting laboratory.

6. A number of cylinders representing each melt of steel are selected at random from a newly manufactured lot and

are subjected to gunfire tests to prove their shatterproof characteristics. No cylinder can show any more damage than the hole inflicted upon it by the projectile used in the test. The oxygen storage cylinder is subjected to an oil content test in addition to other standard tests performed on other gas cylinders. Every precaution is taken from the beginning to prevent oxygen from coming in contact with oil.

7. Before a new or completely expanded supply cylinder can be charged with aviator's breathing oxygen, the inside of the cylinder must be dried and purified by a process known as the HEAT VACUUM TREATMENT.

8. The handwheel valve assembly is the same as those used on smaller aircraft oxygen supply cylinders, and therefore will not be described here. Figure 3–19 illustrates the AVIATOR'S BREATHING OXYGEN storage cylinder.

LOW-PRESSURE OXYGEN CYLINDERS.—These cylinders, A–6, B–3, D–2, F–1, F–2, G–1, and J–1, are cylindrical in shape with hemispherical ends. (See fig. 3–20.)

There are in service two basic low-pressure oxygen cylinders. One is made of stainless steel; the other is of heat-treated low alloy steel. (This low alloy cylinder should not be confused with the obsolete types F–1 and G–1 which were made of stainless steel and not reinforced externally. The F–1 and G–1 can be readily identified because of their plain exterior and one threaded fitting; furthermore, these cylinders are not marked NONSHATTERABLE.) All low-pressure oxygen cylinders are formed to shape and are butt-welded. In the case of the low alloy cylinders, after fabrication each is subjected to a solution heat treatment and a stress relieving heat treatment to provide the requisite physical properties for a nonshatterable cylinder. In addition, the heat treatment removes the segregation of material in the welded zone and provides a seamless cylinder.

The A–6 cylinder has a fitting with ¼-inch pipe threads welded in one end only.

The B–3, D–2, F–1, F–2, G–1, and J–1 have a fitting with ¼-inch pipe threads welded in both ends.

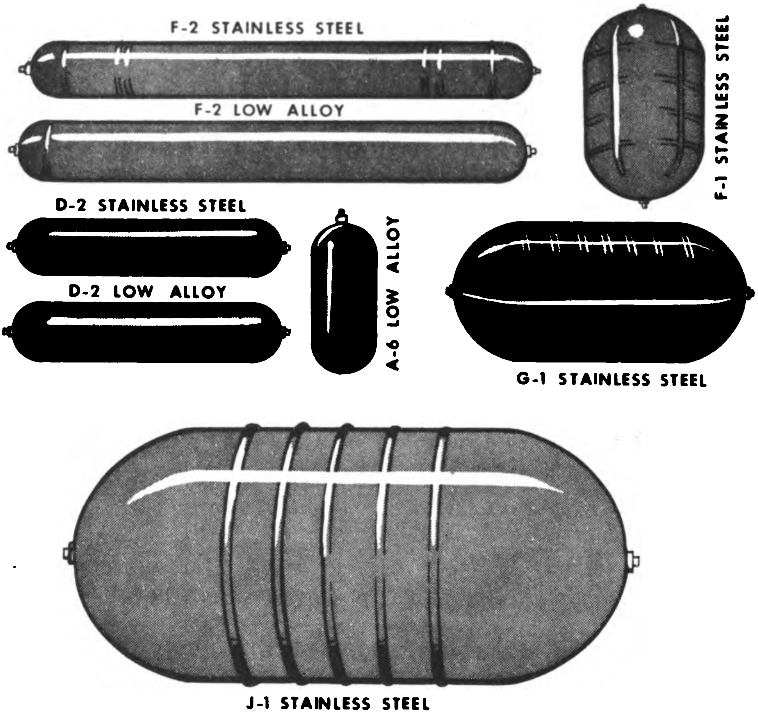


Figure 3–20.—Low-pressure cylinders.

To render the cylinders nonshatterable under gunfire, the types D–2, F–1, F–2, and G–1 stainless steel cylinders are reinforced by addition of narrow bands of stainless steel seam-welded to the body of the cylinder. Indentations are formed in the body section of the J–1 cylinder to impart sufficient strength. Some later type nonshatterable cylinders do not have the reinforced bands, but have a smooth body with the word NONSHATTERABLE stenciled on them.

The cylinders are used in aircraft low-pressure oxygen systems for aviator's breathing oxygen storage containers. The cylinders are installed in the aircraft oxygen system in accordance with specifications for the particular aircraft.

The D–2 and A–6 cylinders are used with the types A–13 and A–15 oxygen regulators as portable oxygen walkaround

Table 3–1.—Low-pressure cylinder data

Types	A–6	B–3	D–2	F–1	F–2	G–1	J–1
Specification Nos. MIL–C–	5435	5436	5887	5888	5889	5890	5891
Minimum internal volume (cubic inches)*	280	280	500	1000	1000	2100	18000
Maximum wt. (lbs.)	3¾	3¾	5	10	11	18	155
Working pressure (p. s. i.)	400	400	400	400	400	400	400
Total oxygen capacity at working pressure (cubic feet)*.	4. 3	4. 3	7. 8	15. 7	15. 7	33. 1	283. 4
Available oxygen in cubic feet**	3. 8	3. 8	6. 9	13. 8	13. 8	29	247. 6
Length (inches)	14½	15	23½	18	44½	24½	49¼
Diameter (inches)	5¾	5¾	5¾	10⅛	5¾	12 9/16	24½
Standard internal pipe threads (inches)	1¼	¼	¼	¼	¼	¼	¼
Number of openings provided	1	2	2	2	2	2	2

*Free gas volume at 400 p. s. i., when expanded to standard conditions, 70° F. (21.1° C.), and atmospheric pressure.
**Free gas volume when used from 400 p. s. i. to a minimum of 50 p. s. i. expanded to standard conditions, 70° F. (21.1° C.), and atmospheric pressure.

assemblies. They are necessary for a person moving around in an airplane at high altitude.

Table 3–1 shows the dimensions, maximum weights, volumetric characteristics and other data of the low-pressure cylinders.

Low-pressure oxygen cylinders are not constructed to withstand pressures much more excessive than 1,000 p. s. i. Their working pressure of 400 p. s. i. is more than four times less than the working pressure of the lowest high-pressure type cylinder. Anyone accustomed to servicing high-pressure systems must be on the alert when he is in the process of charging a low-pressure system. If he is not on the alert and accidentally permits the cascading pressure to build up dangerously, the cylinders will rupture. The sudden release of vast quantities of compressed oxygen can cause a violent explosion, depending on the materials with which it comes in contact.

HIGH-PRESSURE AIRCRAFT OXYGEN SUPPLY CYLINDERS.—The oxygen cylinder and handwheel valve assembly provides a source of breathing oxygen under high pressure (1,800 p. s. i.) for use with high-altitude breathing apparatus.

The oxygen cylinder and handwheel valve assembly consists of a shatterproof steel cylinder and handwheel-operated seat valve to release the cylinder's contents. The handwheel has four $\frac{5}{16}$-inch diameter holes for the attachment of remote-operation equipment if needed.

The valve is equipped with a fusible metal safety plug and a safety disk to release the contents of the cylinder should the pressure become excessive because of high temperatures. The safety plug is filled with a fusible metal designed to melt at temperatures from 98° C. (208° F.) to 104° C. (220° F.).

The cylinder and valve assembly is connected to the oxygen line by brazing the oxygen line tubing to a coupling nose and securing the nose to the valve outlet with a coupling nut. (See fig. 3–21.)

Refer to table 3–2 for information concerning the oxygen rated capacity (cubic feet) and internal volume (cubic inch)

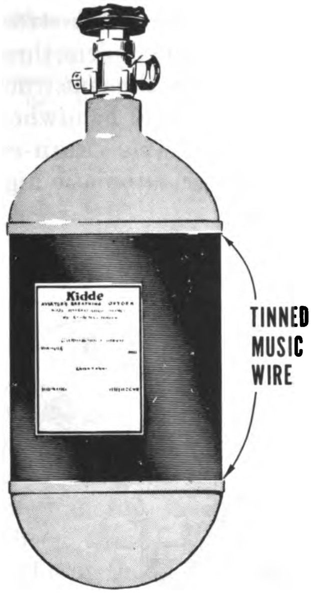


Figure 3–21.—Typical oxygen cylinder and handwheel valve assembly.

of the various sizes of aircraft oxygen cylinders used in high-pressure and reduced high-pressure oxygen breathing systems.

Table 3–2.—Cylinder and valve assembly

Oxygen rated capacity* (cu. ft.)	Internal volume (cu. in.)
7. 15	96. 0
15. 20	205. 0
22. 00	295. 0
38. 40	514. 0

*Capacity at 1,800 p. s. i. charging pressure.

Completely expended cylinders must be purged and dried by personnel in overhaul shops using the heat vacuum treatment prior to charging them for service use. Field activities are not equipped to administer this treatment; therefore, return completely expended cylinders through supply channels. Figure 3–22 illustrates the construction and relationship of parts of the cylinder and handwheel assembly.

SELF-OPENING OR AUTOMATIC HIGH-PRESSURE OXYGEN VALVE.—The self-opening or automatic high-pressure oxygen

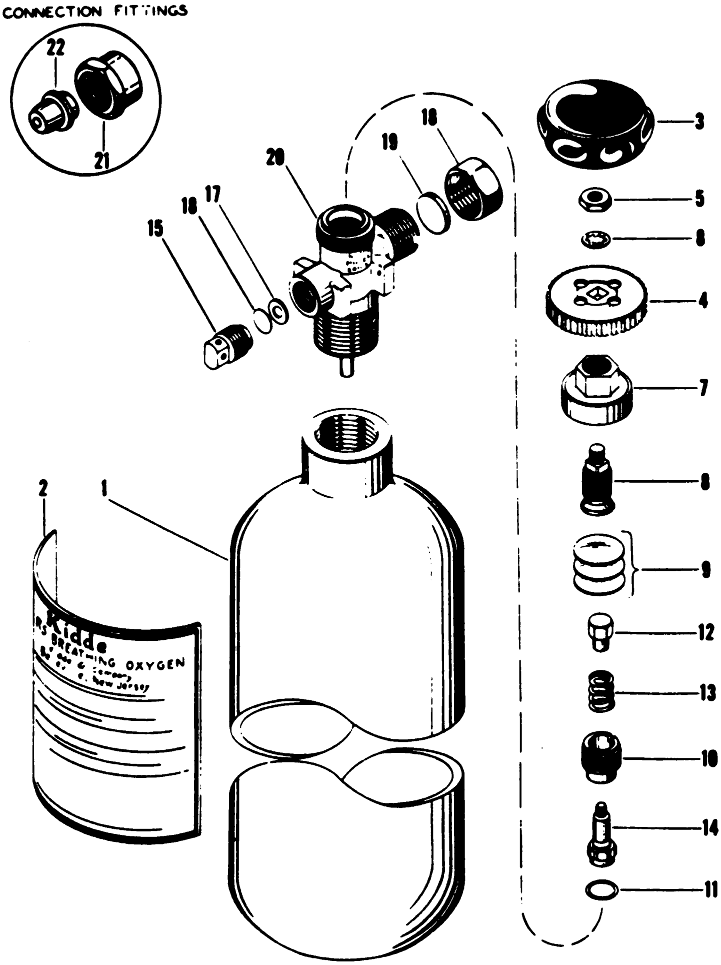


Figure 3–22.—Exploded view—oxygen cylinder and handwheel valve assembly.

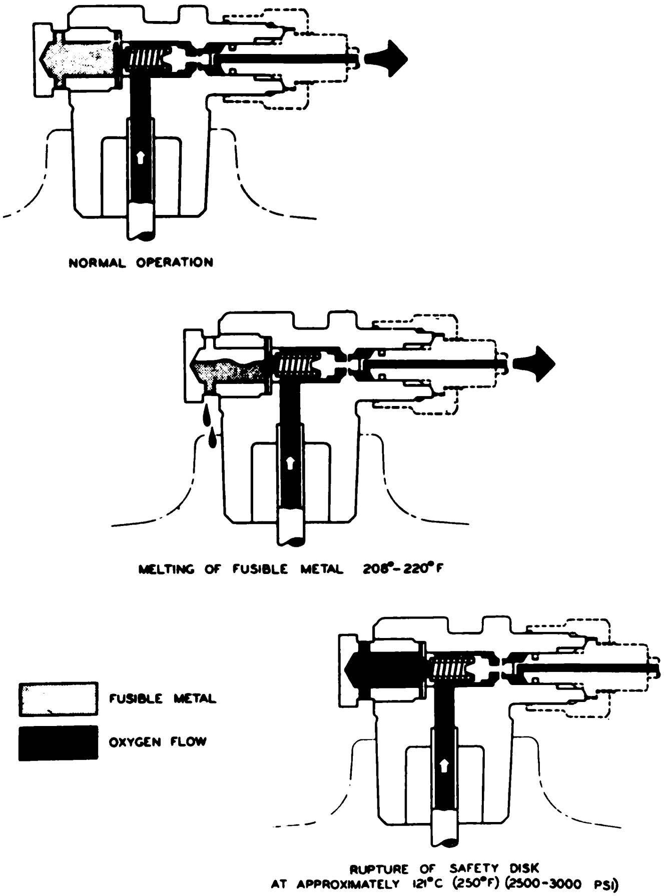
Nomenclature for figure 3–22

1. **Cylinders, 96-, 205-, 295-, and 514-cubic inch internal volume.**
2. **Label—Instruction on Walter Kidde cylinders.**
3. **Handgrips.**
4. **Handwheel.**
5. **Nut, handwheel.**
6. **Washer, lock extension teeth, bronze, No. 10.**
7. **Caps, valve.**
8. **Stem, upper.**
9. **Diaphragm (Set of 3).**
10. **Bushing.**
11. **Gasket, bushing.**
12. **Cap, spindle.**
13. **Spring.**
14. **Seat, valve.**
15. **Plug, safety.**
16. **Disk, safety.**
17. **Washer, safety disk.**
18. **Cap, outlet.**
19. **Washer, outlet cap.**
20. **Body, valve.**
21. **Nut, coupling.**
22. **Nose, coupling.**

valve most commonly installed in 514-cubic inch internal volume aircraft oxygen cylinders is automatically opened when a special nose coupling is screwed into its outlet. After the nose coupling has been fully engaged and the coupling nut has been wrench-tightened, oxygen will flow into the system. The methods available for turning off the cylinder's oxygen supply once the coupling is engaged are to disengage the nose coupling or turn off the supply at the regulator by use of a shutoff valve. In addition, when a line valve is installed between the regulator stations or regulators and the oxygen cylinders or cylinders, it may also be used to shut off the cylinder's supply. It must be understood that all of the above methods are limited, since any service requiring disengagement of a line or instrument between the cylinder and the closest shutoff point will make it necessary to disengage the nose coupling at the cylinder before the service is performed.

The self-opening high-pressure oxygen valve has incorporated in it a distinctive safety feature; namely, a safety plug filled with fusible metal designed to melt at temperatures from 99° C. (208° F.) to 104° C. (220° F.). The purpose of this plug is to prevent premature relief discharge of the oxygen from the cylinder due to increasing pressures. The normal and safety relief operations of the valve are illustrated in figure 3–23.

Study the nomenclature and relationships of self-opening valve parts illustrated in figure 3–24.



NORMAL OPERATION

MELTING OF FUSIBLE METAL 208°-220°F

RUPTURE OF SAFETY DISK
AT APPROXIMATELY 121°C (250°F) (2500-3000 PSI)

Figure 3-23.—Flow diagram of the self-opening or automatic high-pressure cylinder valve.

More than one company is under contract to make these valves for the Navy; therefore, their construction details are slightly different. Know your equipment when connecting a cylinder to a line, and make certain the coupling assembly and O-ring gasket are securely seated and are wrench-tightened.

Drying and testing oxygen cylinders.—The presence of moisture, even in very small quantities, can be transferred

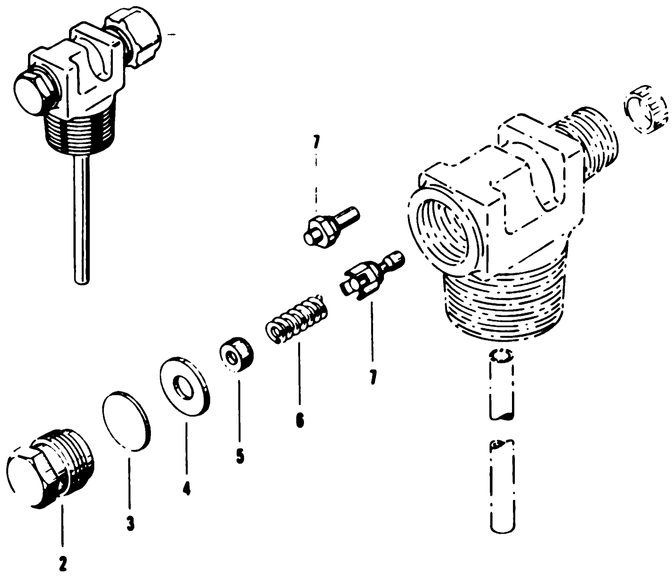


Figure 3–24.—Exploded view—self-opening valve.

1. Self-opening high-pressure oxygen valve assembly.	4. Disk washer.
2. Safety plug assembly.	5. Spring nest.
3. Safety disk.	6. Spring.
	7. Assembly check.

by cylinders that have been allowed to become evacuated to the atmosphere. At low temperatures, moisture deposits in valves and small orifices will freeze and/or prevent oxygen from reaching its respective flight stations. Rust resulting from the moisture might also clog a system. Therefore, uncharged cylinders having a residual pressure below 15 p. s. i. and charged cylinders that must be refinished or that have defective parts (valve) must be voided of residual gas at authorized overhaul shops. All oxygen cylinders that have been opened to the atmosphere for any reason must be returned for overhaul and/or drying out. Expended cylinders may be returned for overhaul through regular supply channels.

HEAT VACUUM TREATMENT.—All aviator's breathing oxygen cylinders shall be put through the HEAT VACUUM PROC-

ESS AT LEAST ONCE A YEAR. The process consists of the following steps:

1. The valve is removed from the cylinder, and the inside is wire-brushed until all rust is removed. A valve is then attached to the cylinder.

2. The cylinder is placed in a specially-designed oven and connected to a vacuum pump. The cylinder is exhausted to an absolute pressure of not more than 1 millimeter of mercury for a period of at least 30 minutes. During this period the temperature of the oven is raised to, and maintained at, 110°+0°−2° C. (230°+10°−4° F.).

3. After the 30-minute baking period the vacuum pump connection is secured, and air which has been passed through a drying tower is then slowly passed into the cylinder.

4. After the return to normal pressure within the cylinder, it is again evacuated and the procedure repeated.

5. After the second evacuation, the cylinder is filled with aviator's breathing oxygen conforming to the latest specification.

New high-pressure cylinders, and those cylinders which have been in service use for a period of FIVE YEARS, are subjected to a proof or hydrostatic test to ascertain their minimun strength characteristics.

HYDROSTATIC TEST.—Each new cylinder or one that has been in service for five years is proof tested under an internal hydraulic pressure equal to $\frac{5}{3}$ of the working pressure for which it was designed. A brief description of this process follows:

1. The wire wrapping of nonshatterable cylinders is removed prior to hydrostatic testing. This removal is necessary to prevent possible loosening of the wire binding straps or the wire winding during such testing. In addition, rust is occasionally found under the wire winding.

2. The cylinder is placed in a vise, and the water jacket cover of the testing device is installed using a rubber gasket. The cylinder and cover are then assembled to the water jacket. All pressure joints must be made carefully to assure absolute watertightness.

3. The water jacket is then filled with water, leaving the

petcock open until the water flows out of it. The petcock is then closed and the level in the burettes adjusted to read exactly zero.

4. The specified internal hydrostatic pressure is then gradually applied to the cylinder by means of the pumps and maintained for 30 seconds.

5. The burettes are observed carefully. If the level fluctuates, the test must be repeated, using a test pressure 100 p. s. i. higher than that of the previous test. If a third test is run, the test pressure is 100 p. s. i. higher than the second test. If the third test fails, the cylinder is discarded.

6. At the end of the test period, the volumetric expansion of the cylinder shall be determined by observing the amount of water displaced into the burettes. Then, the internal pressure on the cylinder shall be gradually released and the permanent volumetric expansion determined by observing the amount of water displaced into the burettes.

7. The cylinder is then removed from the water jacket, placed in a vise, and the water jacket cover is removed.

8. If the permanent expansion of the cylinder is more than 10 percent of the total expansion, the cylinder is drained and then tagged with a "Rejected" tag, showing the reason for rejection.

9. If the percentage of permanent expansion is 10 percent or less, the cylinder is satisfactory, and the date of the test is stamped in the metal on the cylinder shoulder.

10. The nonshatterable cylinder is then rewound with 0.029-tinned music wire.

After the hydrostatic test is completed each satisfactory cylinder is recleaned, the outlet is plugged, and each cylinder is painted externally according to specifications. Then, before it can be put in service it is given the heat vacuum treatment.

Low-pressure cylinders are hydrostatically tested to 1,000 p. s. i. Afterwards they are oven dried and sealed to prevent moisture from entering the outlet spud connections. However, when low-pressure cylinders are installed in a system, the sealing plugs must be removed. In doing this, the atmosphere enters the cylinder. To compensate for any moisture which has passed into the cylinder, and after the connections have been made, the system is purged with oxygen. Purging will remove moisture.

Oxygen Duration

Duration data in general.—The subject of duration, regardless of the number of cylinders or regulators used in a system, is often problematical. A duration chart or graph can only serve to approximate the length of time oxygen will be available for use at a prescribed altitude. This approximation must necessarily be based on an average inspiration rate. One cannot anticipate certain physical conditions which might require an abnormally large supply of oxygen. The actual duration depends upon the following factors:

1. The type of oxygen equipment and how it is used.
2. The number and size of the gaseous oxygen cylinders or liquid oxygen converters.
3. The initial pressure in the cylinders.
4. The altitude.
5. The amount of loss or leakage due to battle damage.
6. The rate and depth of breathing (both of which vary greatly in activity or excitement).
7. Emergencies which may require the use of an exceptionally large amount of oxygen.
8. The temperature at the time the use of oxygen is discontinued.

The first four of these factors are constant or relatively predictable for any particular aircraft and mission. The last four, although equally important, cannot be predicted precisely enough for accurate calculations.

The consumption values given are conservative estimates for determining oxygen duration, based upon the first four factors listed and the anticipated rates and depths of breathing consistent with moderate activity. In using them, it was assumed that no serious leakage or emergency would occur, and that there would be no great change of ground level temperature.

Duration charts.—Duration charts should be provided

APPROX. HOURS OF OXYGEN PER MAN
DIL. DEMAND REGULATOR

PLANE MODEL	NO. MEN	NO. CYLS.	SIZE CYL.
	1	1	514 CU. IN.

AIR VALVE — NORMAL OXYGEN

CYL. PRESS.	ALTITUDE IN THOUSANDS OF FEET						
	10	15	20	25	30	35	40
1800	9.0	8.5	6.9	4.1	3.1	4.2	6.9
1500	7.2	6.8	5.5	3.3	2.5	3.4	5.5
1200	5.4	5.1	4.1	2.4	1.9	2.5	4.1
900	3.6	3.4	2.9	1.6	1.2	1.7	2.8
600	1.8	1.7	1.4	.8	.6	.8	1.4
300	DESCEND BELOW 10,000 FEET						

Figure 3–25.—Duration chart for a 514-cubic inch cylinder.

APPROX. HOURS OF OXYGEN PER MAN
DIL. DEMAND REGULATOR

PLANE MODEL	NO. MEN	NO. CYLS.	SIZE CYL.
	1	1	205 CU. IN.

AIR VALVE — NORMAL OXYGEN

CYL. PRESS.	ALTITUDE IN THOUSANDS OF FEET						
	10	15	20	25	30	35	40
1800	3.6	3.4	2.8	1.7	1.2	1.7	2.8
1500	2.9	2.7	2.2	1.4	1.0	1.4	2.2
1200	2.2	2.0	1.7	1.0	.7	1.0	1.7
900	1.4	1.4	1.1	.7	.5	.7	1.1
600	.7	.7	.6	.3	.2	.3	.6
300	DESCEND BELOW 10,000 FEET						

Figure 3–26.—Duration chart for a 205-cubic inch cylinder.

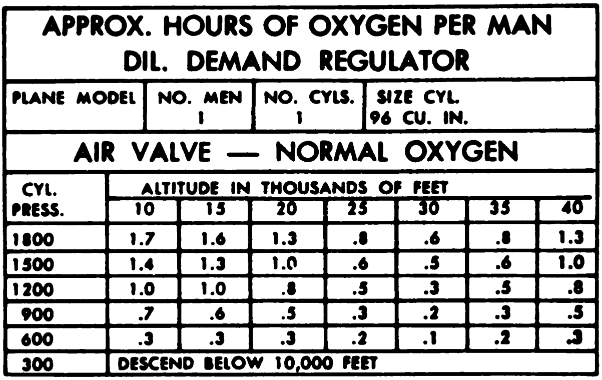
APPROX. HOURS OF OXYGEN PER MAN
DIL. DEMAND REGULATOR

PLANE MODEL	NO. MEN	NO. CYLS.	SIZE CYL.
	1	1	295 CU. IN.

AIR VALVE — NORMAL OXYGEN

CYL. PRESS.	ALTITUDE IN THOUSANDS OF FEET						
	10	15	20	25	30	35	40
1800	5.2	4.9	4.0	2.4	1.8	2.4	4.0
1500	4.2	3.9	3.2	1.9	1.4	1.9	3.2
1200	3.1	2.9	2.4	1.4	1.1	1.4	2.4
900	2.1	2.0	1.6	1.0	.7	1.0	1.6
600	1.0	1.0	.8	.5	.4	.5	.8
300	DESCEND BELOW 10,000 FEET						

Figure 3–27.—Duration chart for a 295-cubic inch cylinder.



APPROX. HOURS OF OXYGEN PER MAN
DIL. DEMAND REGULATOR

PLANE MODEL	NO. MEN	NO. CYLS.	SIZE CYL.
	1	1	96 CU. IN.

AIR VALVE — NORMAL OXYGEN

CYL. PRESS.	ALTITUDE IN THOUSANDS OF FEET 10	15	20	25	30	35	40
1800	1.7	1.6	1.3	.8	.6	.8	1.3
1500	1.4	1.3	1.0	.6	.5	.6	1.0
1200	1.0	1.0	.8	.5	.3	.5	.8
900	.7	.6	.5	.3	.2	.3	.5
600	.3	.3	.3	.2	.1	.2	.3
300	DESCEND BELOW 10,000 FEET						

Figure 3–28.—Duration chart for a 96-cubic inch cylinder.

at every flight station for each aircraft having an oxygen system. Four charts, (figs. 3–25, 3–26, 3–27, and 3–28), based on ONE CYLINDER PER MAN, and regulators 2851 and 2858 are shown covering the four aircraft cylinder sizes with an air valve setting of NORMAL OXYGEN.

CONSUMPTION RATE METHOD OF DETERMINING OXYGEN DURATION.—Duration of oxygen systems using types A–12, A–12A, AN6004–1 and A–14A regulators, by the consumption rate method, is given in table 3–3.

Table 3–3.—Oxygen consumption rate based on cubic feet per hour (corrected to sea level).

Altitude (feet)	Diluter Settings	
	Normal oxygen	100% oxygen
Sea level	4. 87	27. 82
5,000	5. 07	22. 55
10,000	3. 82	17. 85
15,000	5. 07	14. 35
20,000	6. 15	11. 50
25,000	6. 95	8. 75
30,000	6. 57	6. 75
35,000	4. 87	4. 87
40,000	4. 87	4. 87

Example: Assume that the aircraft carries nine type G–1 oxygen cylinders; it is going to fly at 20,000 feet; and there will be 5 crewmembers aboard the aircraft.

The available oxygen from a type G–1 cylinder is 29 cubic feet. (See table 3–1.) Multiply 29 by the number of type G–1 cylinders (9) and you will obtain the total available supply of oxygen, or 261 cubic feet.

At 20,000 feet using NORMAL OXYGEN, a crewmember has a consumption rate of 6.15 cubic feet of oxygen per hour. (See table 3–3.) Mulitply the consumption rate by the total number of crewmembers (6.15×5) and you will obtain a total consumption rate of 30.75 cubic feet per hour.

Now divide the total aircraft oxygen supply by the total consumption rate (261÷30.75) and you will arrive at an aircraft oxygen system duration value of 8.5 hours.

PIONEER COMPARED WITH ARO DESIGN REGULATORS.—The percentage of oxygen delivered at various altitudes will differ somewhat in the several designs of diluter-demand regulators. The duration value with a system using a PIONEER A–12 or AN6004–1 (2858) regulator will be slightly different from one using an ARO AN6004-1 model regulator. The LESSER DURATION VALUE (at any given altitude) of the various designs is given in table 3–3.

HOW TO ESTIMATE OXYGEN DURATION IN FLIGHT.—During flight, especially in combat, there is only one way to make a reasonable estimate of oxygen duration. This is by observing the rate at which the oxygen pressure is falling. Because of the action of the check valves, the puncture of one or more oxygen cylinders will not necessarily have an immediate effect upon the gage pressure, although the loss of part of the supply will affect the rate of oxygen depletion.

EFFECT OF TEMPERATURE CHANGE.—As an aircraft ascends to high altitudes where the temperature is normally quite low, the oxygen cylinders become chilled. As the cylinders grow colder, the oxygen gage pressure is reduced, sometimes rather rapidly. With a 37.8° C. (100° F.) decrease in temperature of the cylinders, the gage pressure can be expected to drop 20 percent. This rapid fall in pressure is occasionally a cause of unnecessary alarm. It does not mean that any oxygen has been lost. All the oxygen is still there. As the aircraft descends to warmer altitudes, the pressure will tend to rise again, so that the rate of oxygen usage may appear to be slower than normal. A rapid fall of oxygen pressure while the aircraft is in level flight, or while it is descending, is not ordinarily due to falling temperature. When this happens, leakage or loss of oxygen is indicated and shall be investigated.

The comsumption rates given in table 3–3 is an average (with safety factor added) of consumption rates from duration data obtained on actual aircraft flights on routine missions and combat missions.

Caution: In estimating oxygen duration from successive gage readings, you assume that the gage pressure will continue to fall at the same rate as it does when the estimate is made. Actually, the rate may vary greatly within a short time. For this reason, estimates should be made at frequent intervals, especially when the aircraft has been exposed to gunfire.

FLIGHT HANDBOOKS.—Oxygen duration charts are published in applicable FLIGHT HANDBOOKS for each model aircraft. As an example, information from the *Flight Handbook of Navy Model AD–5W Aircraft* is given below.

MAN-HOURS PER CYLINDER

ALTITUDE FEET	AIR VALVE	GAGE PRESSURE P S.I								
		1800	1600	1400	1200	1000	800	600	400	BELOW 300
30,000	NORMAL	3.9	3.4	2.9	2.3	1.8	1.3	0.8	0.2	EMERGENCY DESCEND TO ALTITUDE NOT REQUIRING OXYGEN
	100% OXYGEN	3.9	3.4	2.8	2.3	1.8	1.3	0.8	0.2	
25,000	NORMAL	4.5	3.8	3.3	2.7	2.1	1.5	0.8	0.3	
	100% OXYGEN	2.7	2.3	1.9	1.6	1.2	0.9	0.5	0.2	
20,000	NORMAL	5.5	4.8	4.0	3.3	2.6	1.8	1.1	0.3	
	100% OXYGEN	1.9	1.7	1.4	1.1	0.9	0.6	0.4	0.1	
15,000	NORMAL	6.2	5.4	4.5	3.7	2.9	2.1	1.2	0.4	
	100% OXYGEN	1.4	1.2	1.0	0.8	0.6	0.5	0.3	0.1	
10,000	NORMAL	6.1	5.2	4.4	3.6	2.8	2.0	1.2	0.4	
	100% OXYGEN	1.1	0.9	0.8	0.6	0.5	0.3	0.2	0.1	
5000	NORMAL	4.5	3.9	3.3	2.7	2.1	1.5	0.9	0.3	
	100% OXYGEN	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.1	

Figure 3–29.—Oxygen duration chart for composite diluter-demand regulator (Pioneer type) and 514-cubic inch cylinder.

The AD–5W aircraft is equipped with three oxygen cylinders of 514-cubic inch capacity each in the aft portion of the fuselage. Composite diluter-demand type oxygen regulators are installed for the pilot, observer, and radar operator, and are located on their respective consoles.

The number of man-hours of oxygen available for various combinations of oxygen pressure and altitude may be obtained from the oxygen duration chart. (See fig. 3–29.) The chart is based on the installation of one cylinder only used by one crewmember. To obtain the total number of hours available per man, multiply the figure given in the chart by the number of cylinders installed, and then divide by the number of crewmembers being supplied from the system.

Caution: The SAFETY PRESSURE lever must be turned OFF whenever the oxygen mask is not in use. Otherwise, there will be a continuous flow of oxygen from the regulator which will exhaust the supply and, in the presence of oil or grease, will cause a violent explosion.

QUIZ

1. The fusible plug on a high-pressure cylinder valve will melt at a temperature of
   a. 202° F. to 230° F.
   b. 203° F. to 224° F.
   c. 208° F. to 220° F.
   d. 204° F. to 228° F.
2. When mounting the flow indicator directly on the regulator (AN6004–1 series) do not attempt to screw the __________ into the regulator with the flow indicator already attached to the fitting.
   a. 90-degree elbow fitting
   b. 45-degree elbow fitting
   c. 60-degree elbow fitting
   d. 120-degree elbow fitting
3. The instrument used to give a visual indication that oxygen is flowing is the
   a. emergency valve
   b. flow indicator
   c. line valve
   d. cylinder pressure angle
4. The maximum distance that a flow indicator may be installed from a regulator is
   a. 12 feet
   b. 8 feet
   c. 9 feet
   d. 10 feet
5. If a Harris 41–A regulator is incorporated in an oxygen system, the reduced portion of the system will have a pressure of
   a. 50 p. s. i.
   b. 60 p. s. i.
   c. 70 p. s. i.
   d. 80 p. s. i.
6. The duration of the supply of oxygen in a cylinder is computed from
   a. oxygen duration charts
   b. technical orders
   c. technical notes
   d. FURS

7. The DJ–2–1 oxygen flow indicator is a device used with the
    a. diluter-demand oxygen regulator series
    b. demand series
    c. AN6010 regulator
    d. A–15 regulator
8. After blowing into the breather tube and holding the pressure with the tongue (excluding 2867–B1 regulators), the blinker must stay open for
    a. 2 seconds
    b. 3 seconds
    c. 4 seconds
    d. 5 seconds
9. The flow indicator will "blink" on a pressure variance of
    a. ¼ p. s. i.
    b. ½ p. s. i.
    c. 1 p. s. i.
    d. ⅕ p. s. i.
10. The flow indicator is inspected at the same time the regulator is given the
    a. daily inspection
    b. 190-hour check
    c. 120-hour check
    d. 90-hour check
11. The oxygen flow indicator "blinks" upon the intermittent application of from
    a. 4 to 6 inches of water pressure
    b. 5 to 9 inches of water pressure
    c. 5 to 7 inches of water pressure
    d. 4 to 8 inches of water pressure
12. At each inspiration, the pressure in the bellows chamber of the DJ–2–1 flow indicator changes approximately
    a. ⅕ p. s. i.
    b. ¼ p. s. i.
    c. ⅛ p. s. i.
    d. ½ p. s. i.
13. The pressure reducing regulator is designed to
    a. gage pressures
    b. expand pressures
    c. reduce pressures
    d. cascade pressures

14. The pressure gage on the Harris Model 41–A pressure reducer indicates the
    a. regulator working pressure
    b. cylinder pressure
    c. regulator outlet pressure
    d. reduced pressure
15. The Harris 41–A will be found incorporated in the
    a. continuous flow system
    b. diluter-demand system
    c. pressure-demand system
    d. reduced high pressure system
16. The Harris Model 41 regulator is adjusted to deliver an output pressure of approximately
    a. 15 p. s. i.
    b. 12 p. s. i.
    c. 60 p. s. i.
    d. 38 p. s. i.

CHAPTER 4

TUBING AND FITTINGS

TUBING

Tubing needs no introduction. Everyone is familiar with its purpose of conveying liquids and gases. Since our subject is compressed oxygen, we are only interested in a tubing capable of withstanding considerable pressure. This leads to the question of material and construction of the tubing which makes it adaptable for oxygen equipment.

High-Pressure Tubing

Resistance to fatigue failure is an important factor, especially when it is realized that the line pressure in a high-pressure system will at times exceed 1,800 p. s. i. and at other times be as low as 300 p. s. i. Because of this, there is a certain amount of expansion and contraction going on all the time, even temperature changes add to the condition. After being subjected to long periods of changing pressure, any metal will eventually break down. This condition is termed "metal fatigue," and is to be guarded against in both the design and the construction specifications for copper tubing. Steps are taken during installation to prevent fatigue failure of the tubing. Tubing is bent in smooth coils wherever it is connected to an inflexible object, like a cylinder or a regulator. Every precaution that can possibly be taken to prevent the accidental discharge of compressed oxygen because of faulty tubing or a faulty installation is accomplished. Although simple in construction, tubing plays a major role in routing the oxygen from the cylinders to the regulator stations.

All high-pressure tubing is seamless copper tubing, and is manufactured in accordance with strict specifications. It has an outside diameter of $\frac{3}{16}$ inch and a wall thickness of 0.035 inch. For application in high-pressure oxygen installations, copper tubing is type N (soft annealed), and is pressure tested at not less than 3,000 p. s. i.

High-pressure tubing is used between the oxygen cylinder valve and the filler connection in all systems, between the cylinder valve and the diluter-demand regulator inlet in type A–1 systems, and between the cylinder valve and pressure reducer in type A–2 and type B systems.

Copper tubing is in the annealed condition when it is installed. If the installation is such that bent or looped sections of copper tubing are required, these sections are bent to the required form and then annealed prior to installation. When the tubing is installed, it will not require reannealing until after 12 months use. This reannealing process increases its useful life an additional six months, after which new tubing is installed.

In order to connect the tubing, adapters and fittings must be SILVER SOLDERED to its ends. Due to the pressure involved, the security (leak tightness) of all high-pressure systems relies primarily on a metal-to-metal contact of all its fittings and connections. A fitting properly silver soldered to the end of a copper tube will not come loose or leak. The actual silver soldering process will be described later under TUBING FABRICATION.

Flexible High-Pressure Hose

Flexible high-pressure hose is used mainly in transferring oxygen from cascading trailers and recharge stations aboard ship to aircraft. The flexible hose is particularly adaptable to this use as it is specially constructed to resist bending and other abusive practices necessary to the adequate field performance of transferring oxygen.

The hose is a natural rubber-lined tube protected by layers of cord or fiber impregnated with rubber. It is tested to withstand a surge pressure of 3,000 p. s. i., and is in every respect as strong as its copper tubing counterpart. Some types of hose are covered with braided brass or copper wire to improve their wearing qualities. Cracked or badly frayed hose is NOT safe for continued use and should be replaced.

The flexible hose is also used for jumper lines on transfer equipment and in aircraft turret installations where its flexible characteristics insure a safer and longer use.

Figure 4–1 illustrates high-pressure tubing (rigid copper tubing) and the flexible hose. ASO supplies Seamless Round, Annealed Copper Tubing in accordance with specifications in 25- to 30-foot lengths. The 3/16-inch size weighs only 0.065 pound per linear foot, which for all practical purposes of expression, is little more than one ounce per running foot.

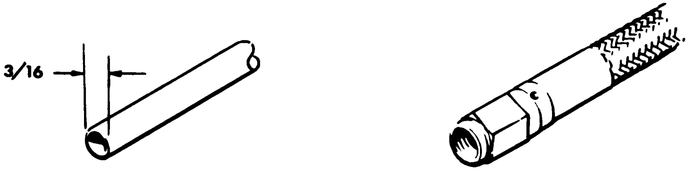


Figure 4–1.—High-pressure copper tubing and flexible hose.

Low-Pressure Tubing

Low-pressure tubing adaptable for use in low-pressure and liquid oxygen systems (450 p. s. i. and 70 p. s. i. working pressure, respectively) is considerably different from the type used in high-pressure systems. The material used is aluminum alloy and the diameter of the tubing is greater. All low-pressure tubing used in oxygen systems is Aluminum Alloy 52 Tubing and is nonheat-treatable. It is manufactured in seamless, round lengths, and is annealed to provide greater flexibility. Aircraft oxygen systems are fitted with 5/16-, 3/8-, and 1/2-inch sizes. Low-pressure tubing (for gaseous oxygen) is installed from the pressure reducer to the outlets in the type A–2 and type B systems. In chapter 5, problems involving mounting and supporting tubing in aircraft will be treated.

Aluminum alloy tubing is issued in 10- to 12-foot lengths. Order tubing in pounds, for example, 5/16-inch, 0.035-inch

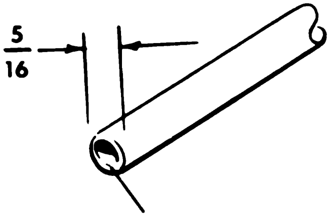


Figure 4–2.—Low-Pressure aluminum alloy tubing.

wall thickness tubing weighs 0.035 pound per foot. The 0.035-inch wall thickness and the weight figure of 0.035 is merely a coincidence. For example, if 30 feet were needed, multiply 30 feet by 0.035 which equals 1.050 or slightly more than a pound, or to be exact 1 pound, 350 grains, since there are 437.5 grains in an ounce. (See fig. 4–2.)

Marking

In order to identify the oxygen lines installed in a maze of other tubing (in the fuselage of an aircraft), it is necessary to mark them in accordance with certain specifications. Oxygen tubing is marked by applying band symbols of tape (colored green and white with BREATHING OXYGEN printed repeatedly on the green band) around the tubing in accordance with the following instruction:

One band shall be located on each tube segment, 24 inches or shorter, provided that both ends of the segment are within

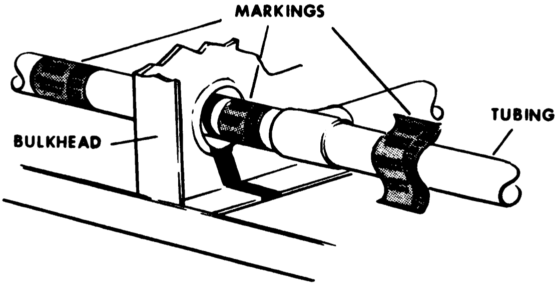


Figure 4–3.—Oxygen line identification.

the same compartment. One band shall be located at each end of each tube segment longer than 24 inches where the tube segment passes through more than one compartment or bulkhead; additional bands shall be applied so that at least one band is visible in each compartment, or on each side of the bulkhead. (See fig. 4–3.)

FITTINGS AND VALVES

The numerous fittings and valves (the connecting members) join the major assemblies to form a common system. Without these connecting devices, oxygen could not flow from the cylinder to a reducing valve, regulator, or any part in a system. However, when the lines are connected, other factors must be considered. These factors are the turning on or off of the oxygen flow, reducing pressure, and directing the flow of oxygen. Actually, all these factors are controlled by the plumbing. A good working knowledge of plumbing and the ability to apply it when working with 90-degree elbows, tees, unions, and all types of valves are required. This information must cover hundreds of different items that are related like washers, gaskets, and clamps, before a successful repair can be effected. As a Parachute Rigger, you will have to have an accurate knowledge of the fittings and valves involved that go to make up high-, reduced high-, and low-pressure systems.

Unless the Parachute Rigger is employed in a specialized job in a major overhaul shop he will not be fabricating an entire oxygen system. His job will mainly be changing lines, valves, and fittings as the field maintenance of the system dictates. Occasionally maintenance problems will require the need for a complete replacement of a tube segment, which can be performed in the field. Many of these segments are issued by the supply system, and are prefabricated and soft annealed ready to install. Under normal conditions, and before fabricating an oxygen line, check the *ASO Catalog* or the *Illustrated Parts Breakdown* for the particular aircraft. Here are listed (if not listed, evidence is given to provide the user with enough information to lead him in the right direction) all the parts fabricated by the manufacturer. The parts are usually illustrated in exploded view form and the accompanying list offers the manufacturer's and sometimes the Navy's part numbers. Navy part numbers are termed stock numbers.

The major difference between tube threads and pipe threads is that pipe threads are tapered and are not as closely cut (tolerances) as tube threads. That is, a pipe thread is smaller in diameter at the tip of its projection than it is at its root. A tube thread is a straight cut thread which is designed to draw a tubing flare or cone union tightly against the mating portion of an appropriate fitting. Tapered pipe threads are designed to seal themselves as the projection is screwed into the internal threads of an aperture. Flared tubing joints are used in low-pressure work; whereas, cone unions (silver soldered previously to the end of a copper tube) form the joining element together with metal recesses in high-pressure fabrications. Consequently, wherever a tube is joined to a fitting projection, that projection must have mating tube threads. Since all external instrument connecting apertures are threaded with internal pipe threads, fitting projections having male pipe threads must be used in conjunction with them.

In a further effort to avoid confusion, study figure 4–4 which illustrates the differences between ⅛-inch tapered pipe and 3/16-inch tubing fittings. It can be seen that a 3/16-inch tube fitting projection does not measure 3/16 of an inch nor does a ⅛-inch pipe thread projection measure ⅛ of an inch, as may have been suspected.

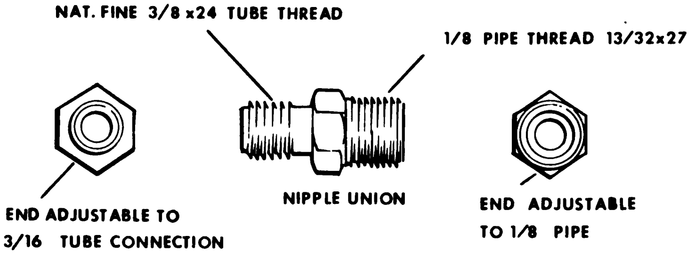


Figure 4–4.—Combination ⅛-inch tapered pipe and 3/16-inch tube fittings.

The NOMINAL DIAMETER of pipe refers to its INSIDE DIAMETER which is controlled by the wall thickness of the pipe. Regardless of strength requirements, the outside diameter of pipe must remain standard in order to be used with standard fittings; therefore it is the inside diameter of the pipe that must change when there is a difference in wall thickness. This variation in wall thicknesses and the nominal (existing in name only; not actual) diameter for ⅛-inch pipe is shown in table 4–1.

Table 4–1.—Dimensions of standard and extra strong pipe

Nominal diameter (inch)	Outside diameter (inch)	Inside diameter (inch)	Thickness (inch)
Standard			
⅛	0.405	0.269	0.068
Extra Strong			
⅛	0.405	0.215	0.095

Notice how the outside diameter remains constant, and how the wall thickness affects the inside diameter. Pipe is not used in the fabrication of oxygen systems, but pipe fitting projections are used in conjunction with connecting tubing to instruments and other items of equipment such as a reducing valve.

Study figures 4–5 through 4–11 for nomenclature and descriptive information relative to the most common type fittings and the check valves used in high-pressure systems.

BRASS and BRONZE fittings are designed for use in HIGH-PRESSURE systems in order to meet strength requirements. Aluminum alloy fittings are specified for use in low-pressure oxygen systems. Do not be confused by the fact that many aluminum alloy-constructed fittings are capable of successfully withstanding higher internal pressure than their bronze or brass counterparts. Strength is not the only factor to be considered when designing an oxygen system. There are

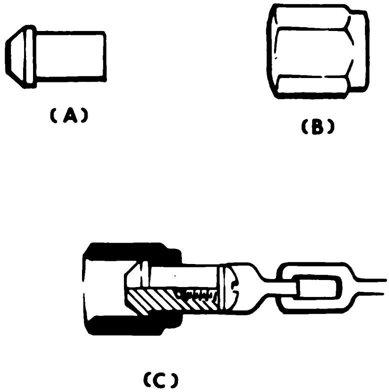


Figure 4–5.—Cone, nut union, and cap. (A) Cone union 3/16-inch brass; (B) nut union 3/16-inch brass, used to connect 3/16-inch tubing to all adaptable fittings; (C) cap, used to cap-off lines.

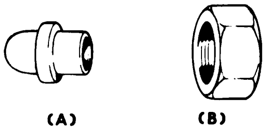


Figure 4–6.—Nose and nut couplings. (A) Nose coupling for connecting 3/16-inch tubing; (B) nut coupling used for securing nose coupling to handwheel type cylinder valves.

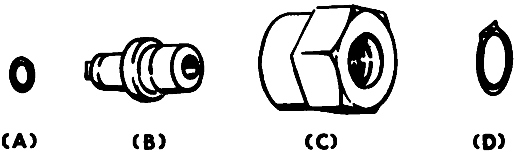
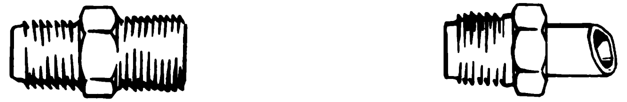
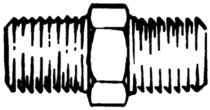


Figure 4–7.—Coupling assembly. (A) O-ring; (B) nose adapter; (C) coupling; (D) Tru-arc ring, used to connect 3/16-inch tubing to automatic cylinder valve.



(A) NIPPLE UNION

(B) COUPLING UNION



(C) NIPPLE PIPE

Figure 4–8.—Nipple and coupling union. (A) Nipple union, 3/16-inch and ⅛-inch pipe, used as a straight connection between instrument and high-pressure line; (B) coupling union, 3/16-inch and brazing end, used as a straight connection between high-pressure lines; (C) nipple-pipe thread, ⅛-inch on both ends, used on high- and low-pressure systems, depending on the material, for a close connection between instruments.

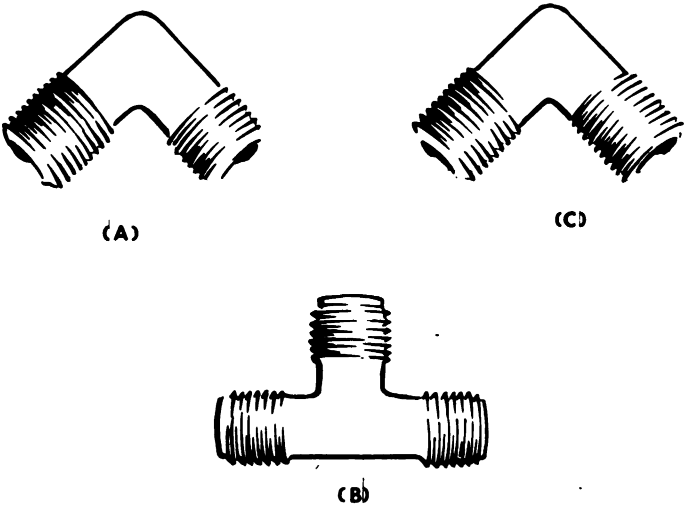


Figure 4–9.—Elbow and tee unions. (A) Elbow union, ⅛-inch pipe and 3/16-inch, used for a 90-degree connection between line and instrument; (B) tee union, 3/16-inch, used as a three-way connection for high-pressure lines; (C) 90-degree elbow, ⅛-inch pipe, threads on both ends, used for instrument-to-instrument connection.

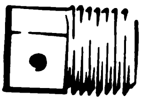


Figure 4–10.—Plug—square head pipe thread, used for sealing ⅛-inch pipe thread holes in instruments. ***Note:*** **This plug is made in plastic as well as brass, bronze, or aluminum alloy. Never use a plastic plug as a permanent seal in an operating system. Plastic plugs are intended for shipping purposes only.**

other characteristics in metals which determine its complete suitability for use under specified conditions. For example: Pipe threads obtain their sealing feature by highly stressed interlocking threads, which, being tapered only, become highly stressed in the final torqued condition. Because of this stress, and the peculiar stress-strain characteristics of aluminum alloy, the threads may deform permanently, causing sufficient misalignment as to make it difficult and occasionally impossible to disassemble a unit. Brass and/or bronze fittings can be tightened to greater torque specifications than aluminum alloy fittings, thereby adequately sealing a high-pressure system against leaks. The dissimilarity of metals and their corrosive action are other factors to be considered. Never permit steel or cast brass fittings to be used in conjunction with aluminum alloy fittings or tubing.

Check valves are used to direct the flow of oxygen in one direction and to check it in the opposite direction. In the event a line is ruptured, check valves (properly installed) will prevent the remaining oxygen in the system from escaping. Arrows embossed on the outside of the body-castings indicate the direction of the flow through the valves. Use of the check valves and fittings are described and illustrated in chapter 5.

High-Pressure Line Valve

Figure 4–12 illustrates the high-pressure line valve which, when installed in a system, facilitates turning the oxygen supply on and off. The high-pressure line valve consists of an upper operating stem with handwheel and thrust bearing included in the valve bonnet, and a lower spring operated

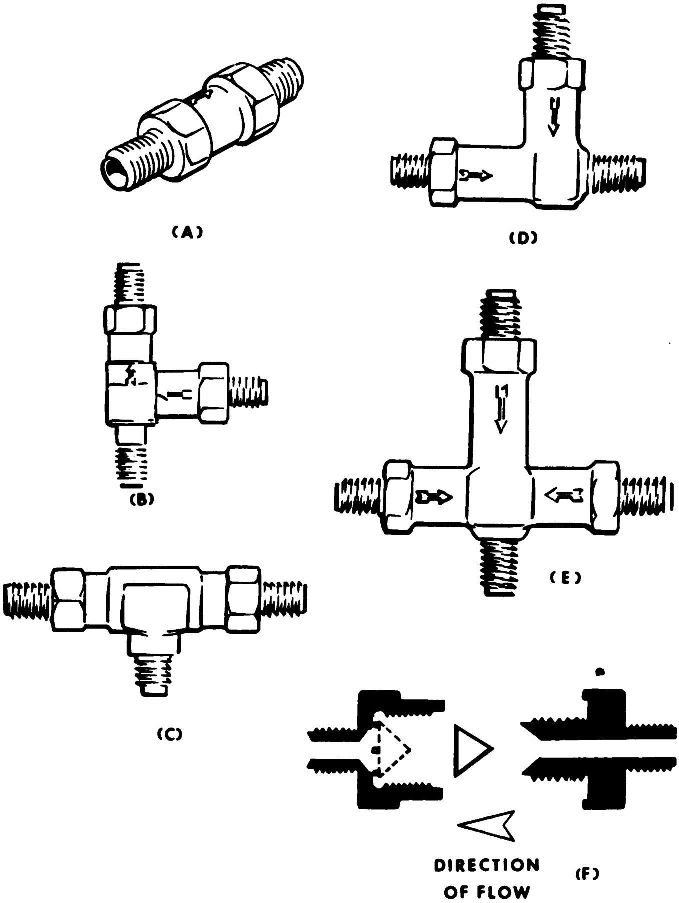


Figure 4–11.—High-pressure check valves. (A) Style A (AN6014–1); (B) style B (AN6015-2); (C) style C (AN6016–2); (D) style D (AN6017–1); (E) style E (AN6018–1); (F) operating principles.

stem with diaphragm and valve seat in the valve body. Turning the handwheel clockwise turns the threaded upper operating stem down on the thrust bearing which in turn bears down on the lower operating stem to close the IN port in the bottom of the valve body. When the handwheel is turned counterclockwise, the upper stem backs off from the

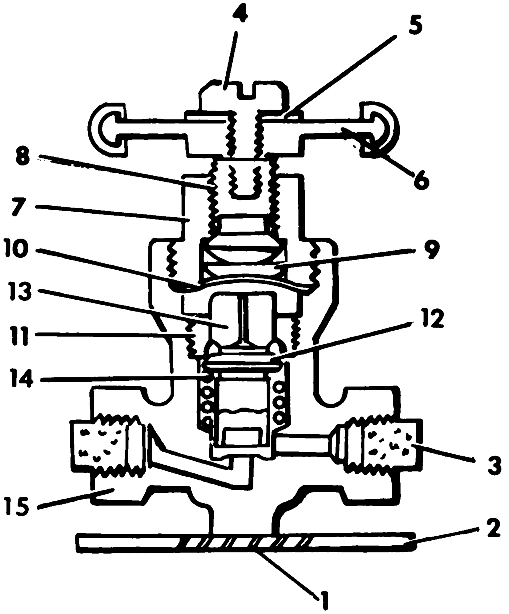


Figure 4–12.—Sectional drawing of a "Superior" high-pressure line valve.

*1. Screw.	9. Bearing.
2. Bracket.	10. Diaphragm.
3. Plug.	11. Bushing.
4. Screw.	12. Gasket.
5. Nameplate.	13. Lower stem.
6. Handwheel.	14. Spring.
7. Bonnet.	15. Body.
8. Upper stem.	

lower stem and the port is opened. A shoulder on the lower stem seats on the guide bushing to prevent leakage around the stem. The diaphragm further prevents leakage from the body into the bonnet. A mounting bracket with four holes on two-inch centers is attached to the bottom of the valve. An arrow on each side of the valve body indicates the direction of flow through the valve.

Filler Valve—Handwheel Type

A handwheel-type filler valve, similar in appearance to the line valve, is illustrated in figure 4–13. This valve operates on the same principle as described above; however, there are external physical differences between the line- and filler-type valves. A 3/16-inch adapter, screwed to the inlet, makes it possible to engage it with the regular 3/16-inch type filling connection used on the end of standard cascade hose. The outlet of the valve is a "male-type" casting (brass), threaded with a 3/16-inch tube thread (UNF thread) for connection with the filler line of the aircraft system. The handwheel-type filler valve is made from a heavy brass casting, and is the kind of bulky item which is being replaced in systems wherever possible with a lighter weight valve.

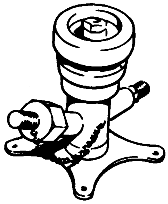


Figure 4–13.—Handwheel type filler valve.

Oxygen Check Filler Valves

Figure 4–14 illustrates two oxygen check filler valves which are used in high-pressure oxygen systems in aircraft. The valves are designed to operate on a maximum normal working pressure of 1,800 p. s. i. Oxygen flows in the direction of the arrows, and is checked in the opposite direction. A filter is installed to remove all foreign matter from the oxygen prior to passing through the check valve and into the aircraft oxygen cylinders.

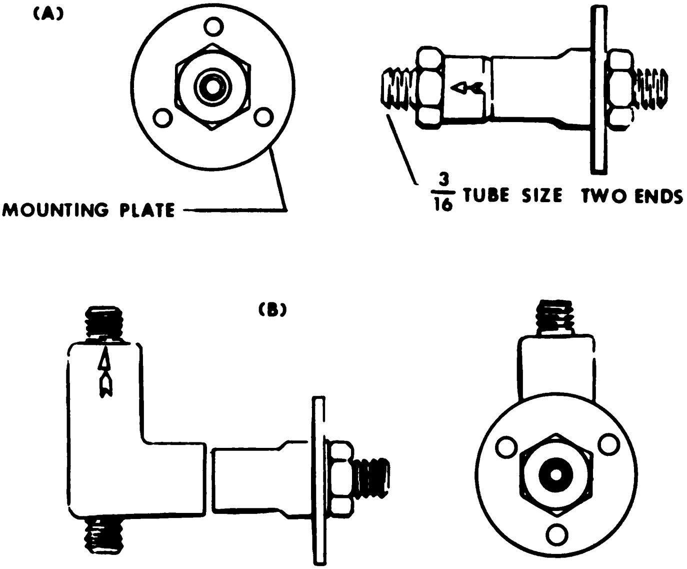


Figure 4–14.—Valve—high-pressure oxygen check filler connection. (A) Style A; (B) Style B.

Pressure Reducing Valve

Figure 4–15 illustrates an oxygen pressure reduction valve. Nonferrous materials are used in its manufacture for all parts except where ferrous materials are necessary. When aluminum and aluminum alloys are used the material is anodized to prevent corrosion. Ferrous materials are cadmium-plated for the same preventive purposes. Every precaution is taken to give all materials coming in contact with oxygen a suitable treatment to prevent a deteriorating condition. As stated earlier, untreated aluminum alloy should never be used with brass; therefore, their use together is limited even though the aluminum alloy product is treated to prevent electrolytic action.

The valve is designed to reduce high-pressure oxygen at the inlet to a relatively low pressure at the outlet. The pressure reduction control is preset and fixed, and does not require operating adjustments. The valve operates from a

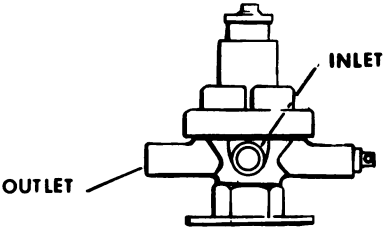


Figure 4–15.—Valve—oxygen pressure reduction.

maximum pressure of 2,000 p. s. i. at the inlet and is preset to a maximum pressure of 400 p. s. i. at the outlet, at no flow. The flow of oxygen would cause a slight fluctuation of pressure, which under actual operating conditions is permissible. An inlet pressure of 300 p. s. i. with 2.5 cu. ft./min. free oxygen flow must produce an outlet pressure of 200 p. s. i. The valve will operate in any position in which it is mounted, and a suitable 200-mesh screen or equivalent filter is adapted to its inlet to prevent dust and other foreign particles entering it. Excessive pressure is relieved by a safety relief valve which prevents the accumulation of a pressure in excess of 600 p. s. i. in the low-pressure portion of the valve body. The valve will shut, after relief, at not less than 500 p. s. i. and it must be leakproof.

Low-Pressure Fittings

Study figures 4–16 and 4–17 where a number of the most common low-pressure fittings are illustrated. The low-pressure fitting, constructed from aluminum alloy stock, is adaptable to the flared tube type connection. Notice the pronounced beveled area on the ends of all male-thread projections. This is the sealing region where the flared tube makes contact.

Low-Pressure Check Valves

Low-pressure check valves (used in gaseous oxygen system), styles A through H, are shown in figure 4–18. Although lighter in weight and constructed of aluminum alloy, they are bulkier than the high-pressure type.

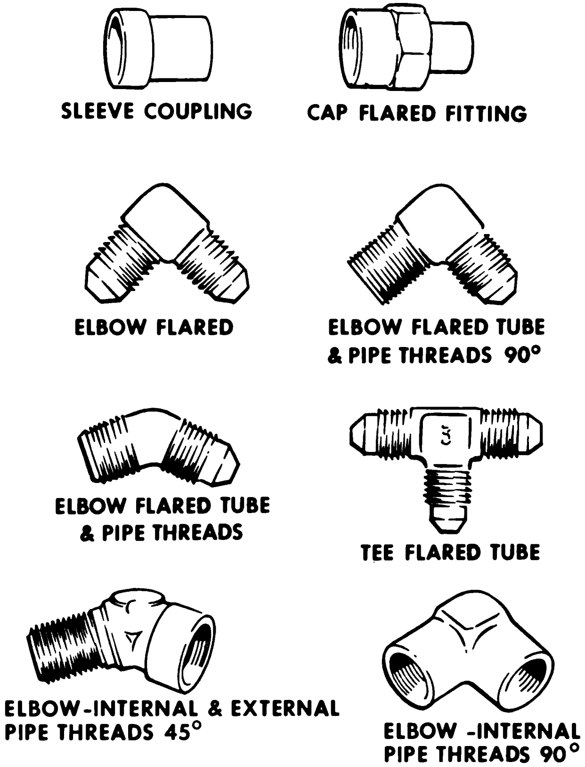
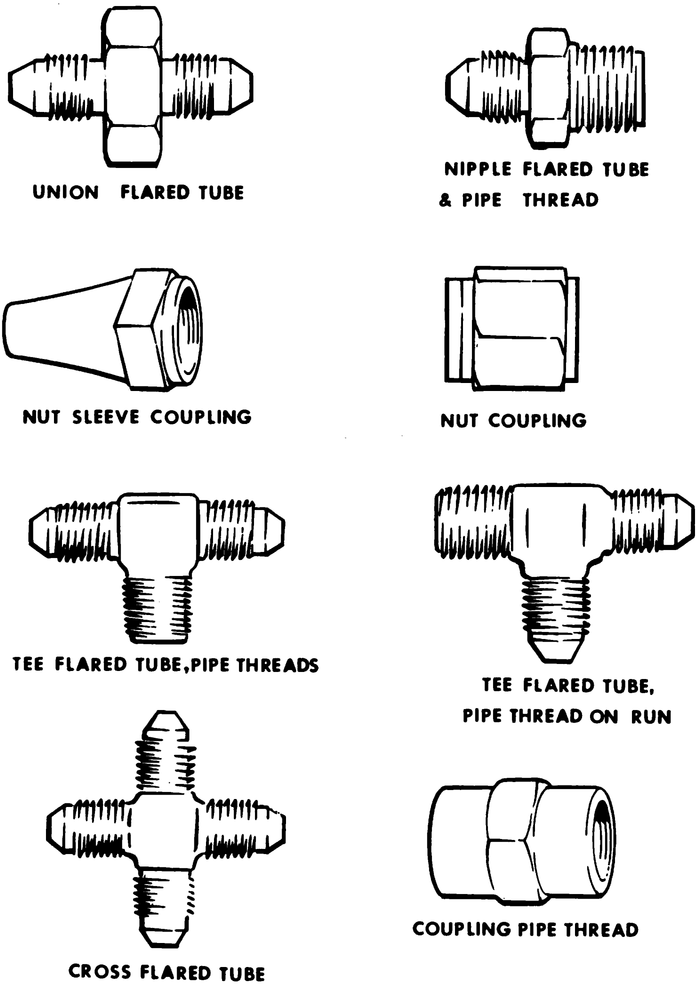

SLEEVE COUPLING
CAP FLARED FITTING
ELBOW FLARED
ELBOW FLARED TUBE & PIPE THREADS 90°
ELBOW FLARED TUBE & PIPE THREADS
TEE FLARED TUBE
ELBOW-INTERNAL & EXTERNAL PIPE THREADS 45°
ELBOW -INTERNAL PIPE THREADS 90°

Figure 4–16.—Low-pressure fittings.

The low-pressure line valve is similar in appearance to its high-pressure counterpart, but is constructed of lighter weight material. Its inlet and outlet connections are adaptable to 5/16-inch flared tube connections. Because of its similarity, the low-pressure line valve need not be illustrated.

Automatic Filler Valve

Figure 4–19 illustrates the low-pressure automatic type filler valve and filler valve projection. The filler valve is used as a recharging receptacle for aircraft systems and walkaround oxygen cylinder assemblies. Walkaround oxygen cylinder assemblies are fitted with a filler valve projection



UNION FLARED TUBE

NIPPLE FLARED TUBE & PIPE THREAD

NUT SLEEVE COUPLING

NUT COUPLING

TEE FLARED TUBE,PIPE THREADS

TEE FLARED TUBE, PIPE THREAD ON RUN

CROSS FLARED TUBE

COUPLING PIPE THREAD

Figure 4-17.—Low-pressure fittings—Continued.

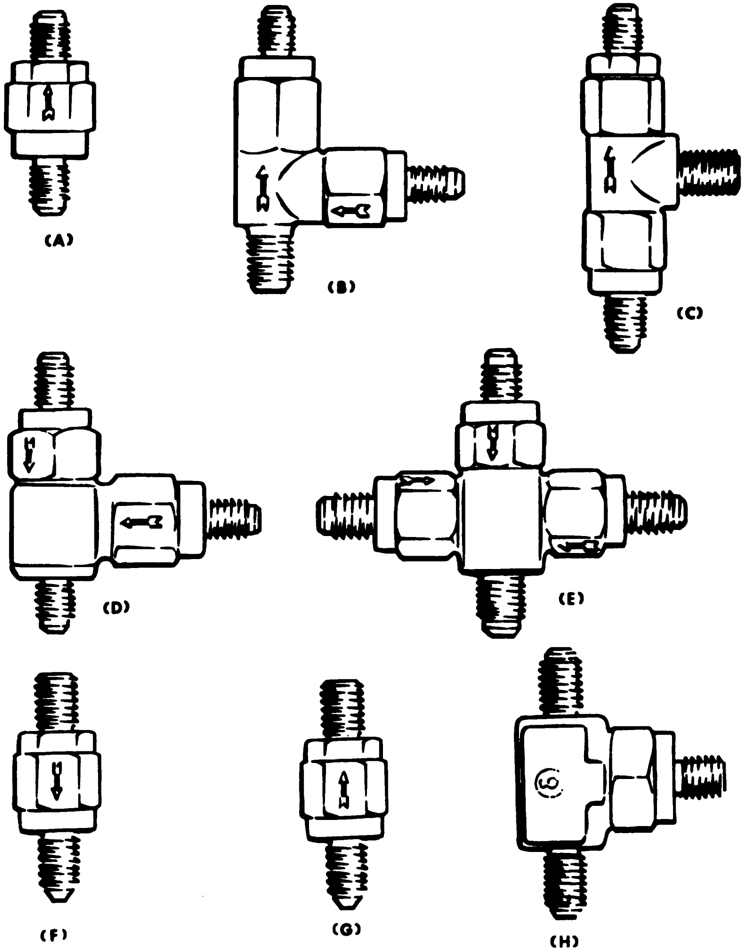


Figure 4-18.—Low-pressure check valves. (A) Style A; (B) style F; (C) style C; (D) style D; (E) style E; (F) style F; (G) style G; (H) style H.

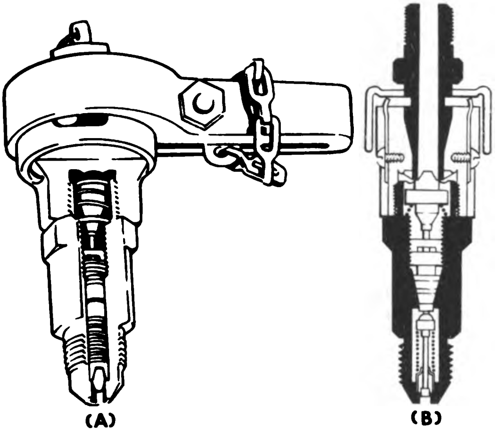


Figure 4–19.—Automatic filler valve and filler valve projection. (A) Automatic filler valve; (B) filler valve projection.

(AN6027–1) which, when injected into the AN6024–1 type valve, opens the check of the automatic filler valve and permits higher pressure oxygen to flow into the cylinder. When the filler projection valve is withdrawn from its filling receptacle, the oxygen flow, back through the filling receptacle, is automatically stopped by a check unit. The filler projection which is not fitted with a check unit would lose the oxygen pressure it had been instrumental in transferring if it were not threaded in an assembly which contained a check valve. In other words, the filling projection (termed a filler valve) does not have a self-contained check valve, and must be threaded in an element which is capable of checking the backflow of pressure in the unit to which the filler valve projection is attached. All low-pressure walkaround units are equipped with filler valve projections, threaded into the bodies of the regulators, which are designed to be used in conjunction with the automatic filler valve.

The flow through a filler valve projection fitted with a high-pressure line valve is controlled by the action of a handwheel acting on its valve stem and seat. The latter arrangement is often used on the end of a recharging trailer hose designed to recharge low-pressure aircraft systems.

Recharger Assembly

Figure 4–20 illustrates a recharger assembly teed into a low-pressure 5⁄16-inch oxygen distribution line. Acting as recharging stations for portable walkaround units, they are installed in accessible locations throughout the aircraft fuselage.

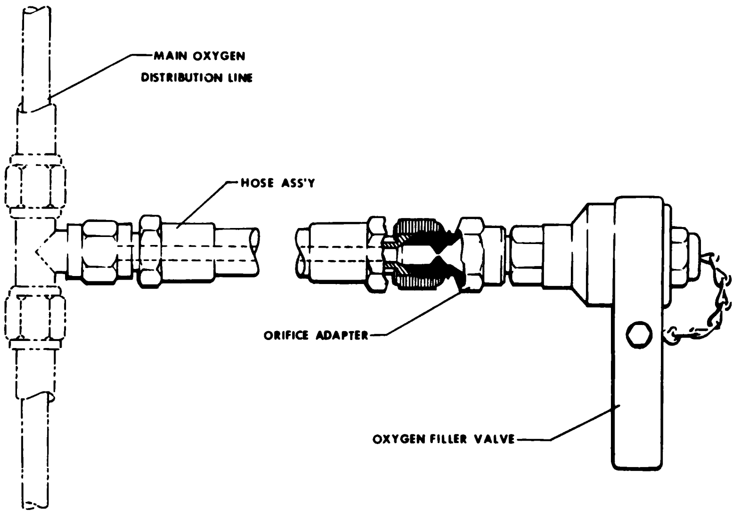


Figure 4–20.—Recharger assembly, portable oxygen.

Automatic Coupling Outlets

Automatic coupling outlets are used to dispense oxygen to passengers, troops, or litter patients in transport aircraft. The automatic coupling consists of a metering orifice and a check unit. Oxygen is delivered to the automatic coupling from types A–11 and AN6010–1 regulators. The purpose of the coupling is to meter oxygen to an oxygen mask (A–8B type). When the mask hose bayonet connector is connected to the automatic coupling, the check unit is connected to the automatic coupling, the check unit is opened, and oxygen flows to the mask. Disconnecting the bayonet fitting automatically closes the check unit in the coupling which is spring

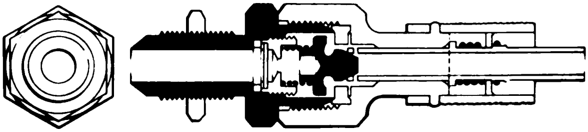


Figure 4-21.—Automatic couplings (AN6009) and fitting assembly coupling.

activated to secure an airtight seal, and to prevent loss of pressure from the line. (See fig. 4-21.)

Swivel Joint

The swivel joint is used in aircraft oxygen systems to convey oxygen to rotating gun turrets and sighting station operators. The swivel joint is capable of 360 degrees rotation in either direction, at 12 revolutions per minute with a maximum torque of 35 pound-inches for all oxygen pressures up to 450 p. s. i., without leakage. (See fig. 4-22.)

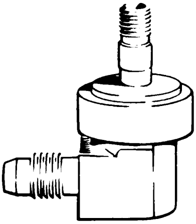


Figure 4-22.—Oxygen swivel joint (AN6042-1).

TUBING FABRICATION

In low-pressure oxygen systems, aluminum alloy lines are used with flared end aluminum alloy fittings or specially treated fittings where design specifications make it necessary for materials other than aluminum alloy to be used.

Damaged tubing should be replaced with new sections; this holds true for high-pressure tubing as well as aluminum. If an aluminum alloy line assembly is to be replaced by reason of irreparable damage, the fittings can likely be salvaged so that replacing the assembly usually amounts to tube replace ment only. High-pressure copper tubing presents a slightly different problem, since couplings are silver soldered to the tubing ends. Silver soldered couplings can be salvaged under emergency conditions by "sweating" them off the ends of the old tube for re-use on a new one. However, any copper tubing assembled under these conditions must be replaced as soon as practicable with new material. The brass coupling nuts, which are merely passed over the tube and are not silver soldered, may be re-used. During the process of removal, the line assembly should be removed without further damage or distortion as it can be conveniently used as a forming template, allowing an exact duplication of length, bends, and angles. If, for some reason, the lines must be rerouted, a new template can be made from wire, interconnecting the original fittings, and bent in a manner similar to that desired in the new tube assembly.

A piece of aluminum alloy tubing, $\frac{5}{16}$-inch diameter, should be cut approximately 10 percent longer than the length of tubing to be replaced. After the required bends have been made, the new tube may be $\frac{1}{2}$ to 2 inches longer than the old tube. (This is the flare allowance and is not considered wasteful since a minimum of at least a $\frac{1}{2}$ inch is needed to flare the ends of the tube.) Allowances should be made for the flaring operation to follow. With copper tubing, extra allowances for length, except for bend allowances, are not necessary as the ends are not flared but fitted with coupling connections. Brass couplings extend the copper tube length by their projecting measurements; therefore, it will be necessary to take this into consideration when fabricating high-pressure tubing at a fixed distance between connections.

As a general rule, keep the length of tubing used between connections to a minimum. However, do not select a straight-line route from one fitting to another even though they may be located on the same plane and in a straight line. Use a bend or a coil in making the connection. In this way, the tubing will be better able to absorb vibrations and pressure variances.

A tube cannot be cut or flared accurately enough to that it can be installed without bends and still avoid initial mechanical strain on the tube. In all cases the new tube assembly should be so formed prior to installing that it is NOT NECESSARY TO PULL the assembly into alignment by means of the coupling nuts. When the tubing is received from stock it should be cleaned before bending, cutting, and flaring. Of course, the straight-line rule cannot be applied in every case. Very short distances cannot be abridged any other way except in a straight line.

Silver Soldering Copper Tubing

Silver soldering is one of several methods of brazing. Brazing originally meant joining with brass, or "brassing."

As the process was improved and new joining alloys were developed, the term assumed its present meaning—a group of thermal joining processes in which the bonding material is a nonferrous metal or alloy (ferrous metals contain large percentages of iron) with a melting point higher than 800° F., but less than the metals being joined. Brazing, therefore, includes silver soldering, bronze welding, and hard soldering.

Silver base solders are used in aircraft work to repair items which must withstand vibration and high temperatures. A high-pressure oxygen line normally will not get hot, but it will be subjected to vibrations, to a fair degree of heat, and 1,800 p. s. i. internal pressure. Silver solder is used extensively to join copper tubing to brass end-fittings. It can be obtained in several different grades with a silver content ranging from 14.5 to 66 percent and with melting points varying from 1,160° to 1,430° F. The standard forms of silver solder are strips and wires. It is also made in rod form. For joints requiring the solder to be applied after heating, use the wire form. Tube end-fittings are in this category. A class 4 silver solder made up of 50 percent silver, 15 percent copper, 16 percent zinc, and 17 percent cadmium is recommended for all general-purpose work with brass, copper, and ferrous metals. Class 4 silver solder will melt at 1,160° F. and flow freely at 1,175° F. Copper tubing will melt at 1,981° F., while brass melts at 1,660° F. From these figures, it can be seen that it is easy to overheat the metals during the brazing process.

The use of flux is absolutely necessary in all silver soldering operations. Flux removes oxide films covering the base metal and makes it possible for the silver solder to come in direct contact with the metal. A paste flux is generally used for most silver soldering; and if a prepared flux is not available, a mixture of 12 parts of borax and 1 part boric acid is satisfactory for high-melting-point silver solder. Prepared flux begins to melt at 800° F., becomes fluid at 1,100° F., and remains stable up to 1,600° F. In other words it melts at a slightly lower temperature than the solder.

The joint must be physically clean, which means free from all dirt and minus all traces of oxide film. After removing all traces of dust or dirt, remove any oxide which may be present by filing the piece lightly until the bright metal can be seen. During the soldering operation, the flux continues the process of keeping oxides away from the metal. Joints to be silver soldered must have smooth edges and must fit tightly together. Only a film of silver solder is usually needed for a round joint. Strength is not added to the joint and expensive solder is wasted if it is used as a filler metal. For strength equal to that of the base metal in the heated zone, the amount of lap should be four to six times the metal thickness for small diameter tubing.

The oxyacetylene flame for silver soldering should be neutral (fig. 4–23), but may have a slight excess of acetylene. It must be soft, not harsh. During both preheating and application of the solder, hold the tip of the inner cone of the flame about one-half inch from the work. Keep the flame moving so that the metal will not be overheated. If the piece is large, preheat a considerable area around the joint before applying the solder, especially if the base metal conducts heat rapidly. When soldering two pieces which have different thicknesses (3/16-inch tubing and a nose coupling), or which conduct heat with unequal speed, gage the preheating so that both parts reach the soldering temperature at the same time. When both parts of the base metal are at the right temperature (indicated by the free flow of flux), begin applying solder to the surface at the top of the tube immediately behind the projection of the fitting as shown in figure 4–23. Continue directing the flame over the whole seam or joint while applying the solder, and keep the flame moving so that the base metal remains at an even temperature. It is important to keep the flame moving as the slightest hesitation of the hand may cause the lower melting-point brass fitting to be deformed.

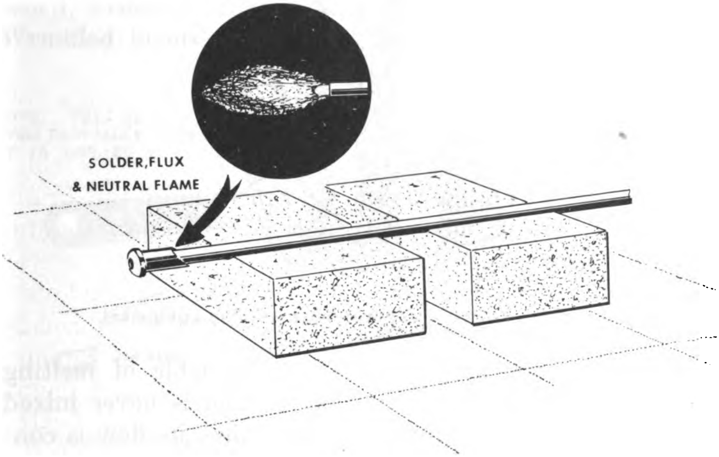


Figure 4–23.—Silver soldering high-pressure brass fittings to $^3/_{16}$-inch copper tubing.

Oxyacetylene Welding Equipment

The portable equipment illustrated in figure 4–24 is generally secured on a hand truck, to an end of a bench, or to a bulkhead. The equipment consists of the following:

1. Two cylinders, one containing oxygen and the other acetylene.
2. A welding torch with necessary tips and mixing head.
3. Lengths of green or black oxygen hose and red or maroon hose for acetylene.
4. Miscellaneous items such as goggles, friction lighter, wrench, and fire extinguisher.

Oxygen and acetylene gas, burned together, through a common system, terminating at the tip of a torch, produce

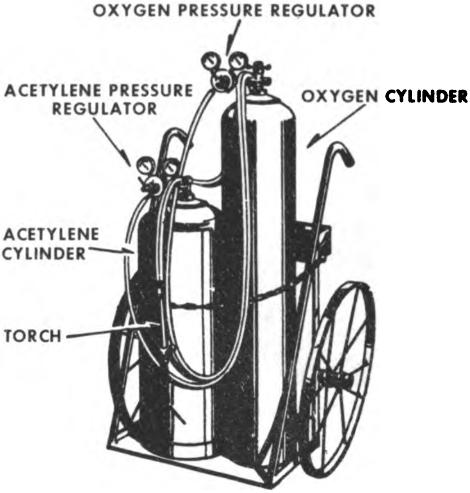


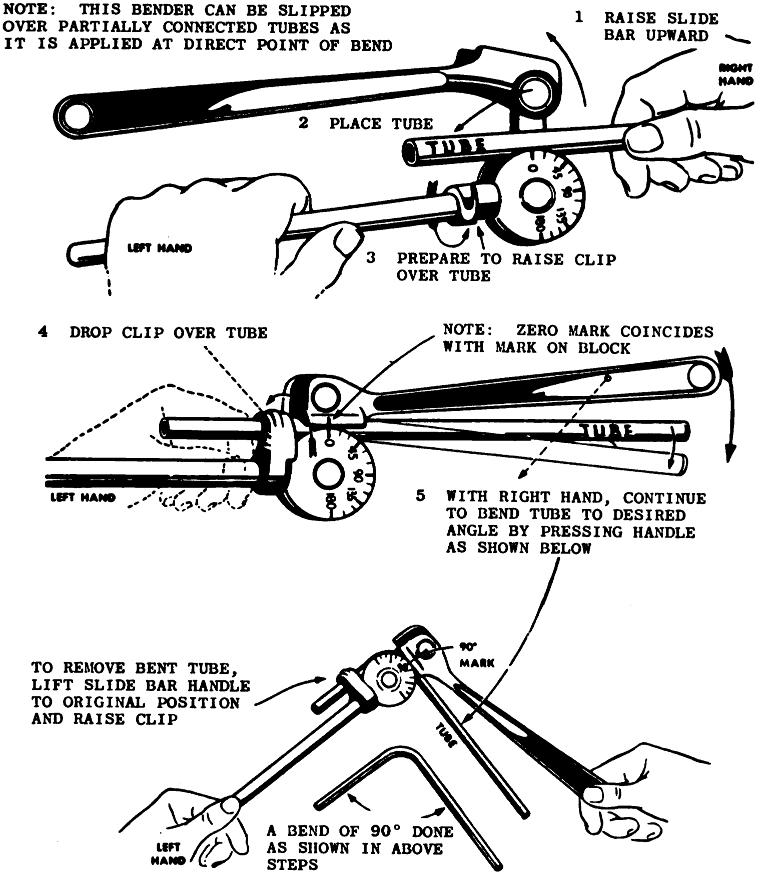
Figure 4-24.—Portable oxyacetylene welding equipment.

an extremely high temperature flame capable of melting metals. Remember, however, that oxygen is never mixed freely with any other commercial gas unless its flow is controlled through a specially-designed system.

Parachute Riggers should have a qualified welder instruct them in the limited requirements involved in the silver soldering process. Do not attempt to use welding equipment until you are thoroughly familiar with the necessary operating safety precautions. One must practice the steps involved in silver soldering before attempting to perform the process on service equipment. After a fitting has been silver soldered to a tube, the entire assembly must be thoroughly cleaned (inside and out) of all foreign matter before it can be installed in an oxygen system. (Cleaning will be discussed later in the chapter.) A squadron Parachute Rigger should always have a supply of silver solder and flux on hand for emergency use, since all metal shops do not carry these items as standard equipment.

Tube Bending

Never use a fitting where a bend in the tube will serve as well. Tube bends are lighter, cheaper, and less troublesome than fittings. Bends in low-pressure oxygen tubing should have a radius of curvature of at least $^{11}/_{16}$ inch and should begin not less than 2 inches from the nearest flare. Flattened, wrinkled, or irregular bends should not be installed. Wrinkled bends usually result from trying to bend thin-


NOTE: THIS BENDER CAN BE SLIPPED OVER PARTIALLY CONNECTED TUBES AS IT IS APPLIED AT DIRECT POINT OF BEND

1 RAISE SLIDE BAR UPWARD

2 PLACE TUBE

3 PREPARE TO RAISE CLIP OVER TUBE

4 DROP CLIP OVER TUBE

NOTE: ZERO MARK COINCIDES WITH MARK ON BLOCK

5 WITH RIGHT HAND, CONTINUE TO BEND TUBE TO DESIRED ANGLE BY PRESSING HANDLE AS SHOWN BELOW

TO REMOVE BENT TUBE, LIFT SLIDE BAR HANDLE TO ORIGINAL POSITION AND RAISE CLIP

A BEND OF 90° DONE AS SHOWN IN ABOVE STEPS

Figure 4–25.—Steps in tube bending.

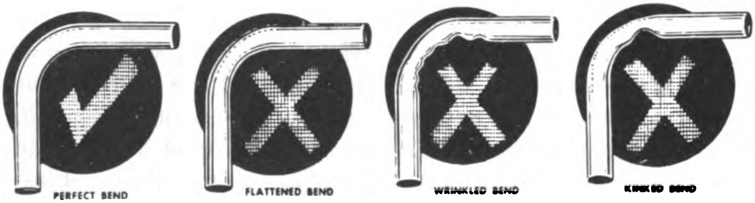


Figure 4–26.—Good and bad tubing bends.

walled tubing without using a tube bender. ALUMINUM ALLOY TUBING FOR OXYGEN SYSTEMS SHOULD NEVER BE HAND BENT. To make acceptable bends use the hand tube bender (figs. 4–25 and 4–26), not to exceed $\frac{5}{16}$-inch size, as follows:

To insert the tube bender, hold the block handle stationary in the left hand and raise the slide bar handle as far as it will go. Raise the clip and drop the tube into place.

Drop the clip over the tube and turn the slide bar handle about its pin so that the full length of the groove in the slide bar is in contact with the tube. Note that the zero

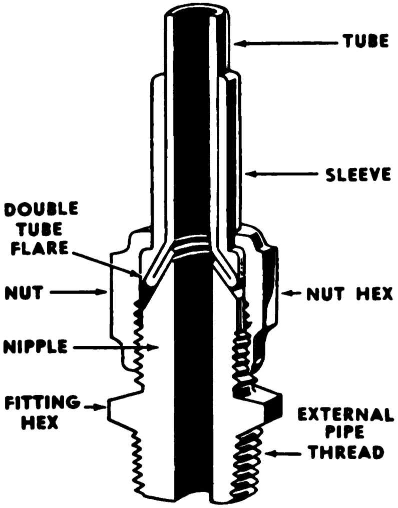


Figure 4–27.—Proper doubled flared tube connections.

mark on the block will coincide with the mark on the slide bar.

Pull the handle until the mark on the slide bar coincides with the mark for the desired angle on the block.

When replacing tube assemblies in oxygen systems, and when making tube assemblies for new installations, only double flares shall be used. A doubled flared 5/16-inch tubing is shown in figure 4–27.

Tube Flaring

The procedure for making a double flare is as follows:

1. Clamp the tubing in the proper size die block (fig. 4–28 (A)) with the flat ends of the blocks toward the end of the tubing to be cut off. Cut the end of the tubing flush and square. Dies can be held in the tool body or vise while the cut is being made. (See fig. 4–29.) In cutting the tube, rotate the cutter toward its open side, gradually feeding the cutting wheel downward by turning the thumbscrew. Do not feed the wheel too rapidly. THE CUTTING WHEEL SHOULD ONLY BE FED WHILE THE CUTTER IS BEING ROTATED, AS DENTS WILL BE CAUSED IN THE TUBING WHEN THE WHEEL IS FED WHILE THE CUTTER IS NOT MOVING. Moderate or light tension on the thumbscrew will maintain an even tension

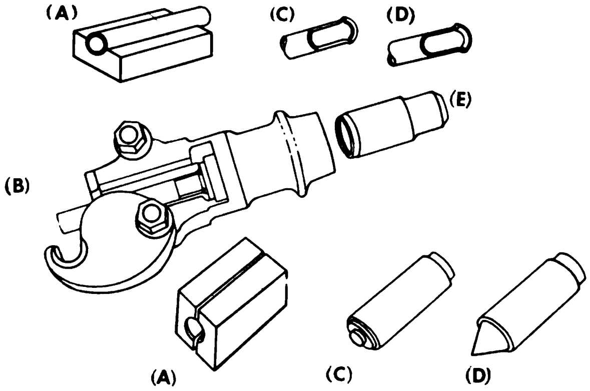


Figure 4–28.—Double flare tool.

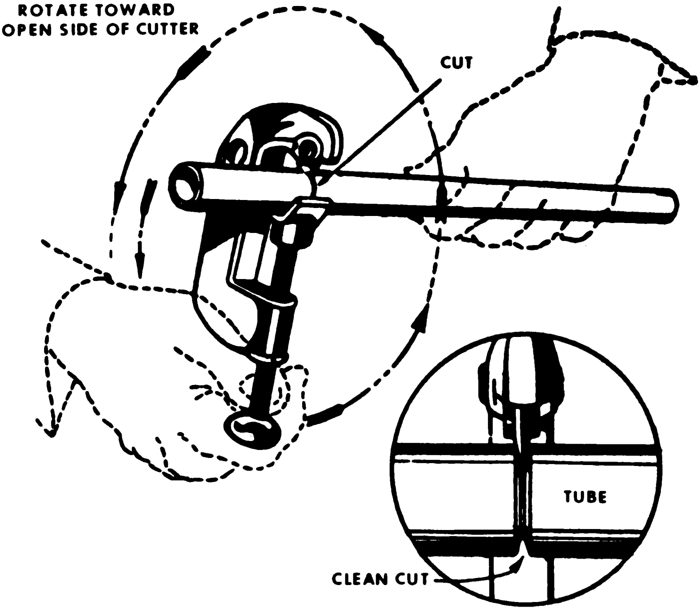


Figure 4–29.—Tube cutting.

on the cutting wheel. This prevents bending and avoids excessive burrs on the soft tubing. If a cutter is not available, use a hacksaw blade with 32 teeth per inch.

2. Remove the tubing from the die blocks and deburr the inside and outside edges as shown in figure 4–30.

3. To install tubing in the tool body for flaring or beading, place one-half of the die blocks in the tool body with the COUNTERBORED end toward the ram guide. Lay the tubing in the block with approximately ½ inch protruding beyond the end. (See fig. 4–28 (B).) Fit the other half of the block into the tool body, close the latch plate and tighten the nuts "fingertight," Select the correct size UPSET FLARE PUNCH. One end of this punch is hollowed out to gage the amount of tubing necessary to form a double-lap flare. (See fig. 4–28 (C).) Slip the punch into the tool body with the gage end toward the die blocks. Install the ram (fig. 4–28 (E)), then

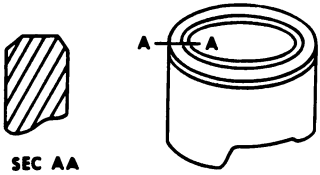


Figure 4–30.—Properly deburred tube.

tap lightly until the punch meets the die blocks and they are forced securely against the stop plate.

4. Using a wrench, draw the latch plate nuts down tight to prevent the tube in the blocks from slipping. Tightening the nuts alternately, beginning with the nut on the closed side, will prevent distortion. Reverse the punch, putting it back into the tool body. Install the ram and tap it lightly until the face of the upset flare punch contacts the face of the die blocks. Remove the ram and the punch.

5. To complete the flare, insert the FINISH FLARE PUNCH and the ram into the tool body. Tap the ram until a good seat is formed (fig. 4–28 (D)). The seat should be inspected at intervals during the finishing operation to avoid overseating. It takes practice to make a perfect double-lap flare. (See fig. 4–31 (A).)

Incorrect double flares shown in figure 4–31 should not be used. In either case, the flare should be cut off and done over. A short inner flare (fig. 4–31 (B)) should not be used because of the short bearing surface for the fitting nipple. This condition may be caused by inserting the tube too low in the clamp blocks or by slippage of the tube during flaring, which is a result of improper tightening of the plate nuts or dirt in the die blocks. A long inner flare (fig. 4–31 (C)) should not be used, because it would restrict the flow passage. This condition is caused by improper gaging.

In an emergency, the tubing can be flared by the conventional single flare method if a double flaring tube is not available. Double flares are smoother, more concentric, more resistant to the shearing effect of torque, and they greatly reduce leakage problems.

When making a flare, all surfaces coming in contact with

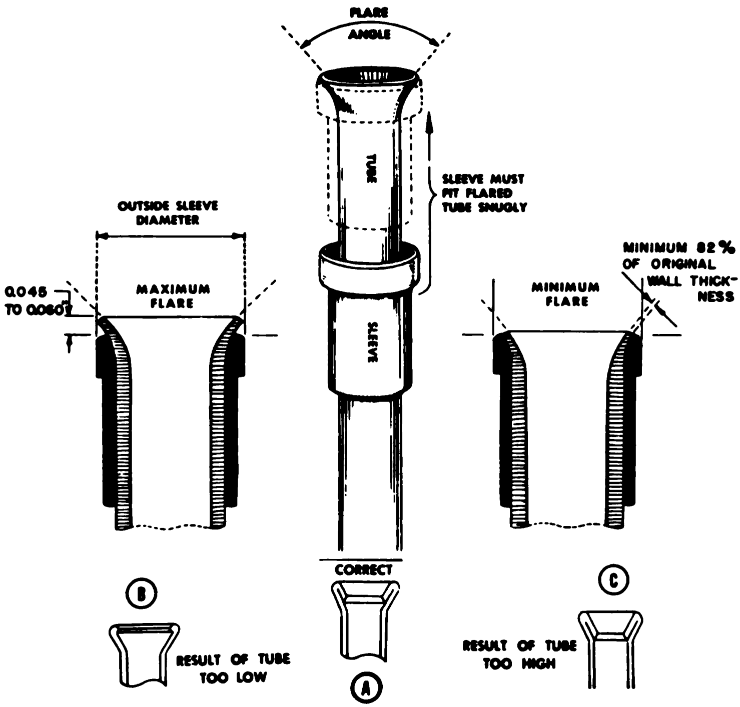


Figure 4-31.—Tube positions and resulting flares.

the tubing must be free from dust, dirt, particles of sand, and any other foreign substance capable of pitting and scratching the tubing.

Flared Oxygen Tube Connections

In low-pressure systems, the parts are joined by means of flared tube connections, or with adapters where necessary, to attach them to pipe thread fittings. A flared tube connection consists of a nipple held against the mouth of the flared tube by a sleeve and a coupling nut. The fittings provide tight connections by means of metal-to-metal contact. The flared end of the tubing is pressed tightly against the nipple when the parts are assembled. (See fig.

4–27.) Only AN aluminum alloy flared fittings are used in low-pressure oxygen systems.

Leakage at oxygen fittings may sometimes be corrected merely by tightening. Excessive tightening, however, will weaken or destroy the connection rather than improve it. A torque wrench should be used in tightening flared tube connections.

Where SINGLE FLARES are already installed, the fittings should never be tightened with a wrench torque greater than 100 INCH-POUNDS. If the leak cannot be stopped, the line assembly should be replaced with a line assembly having double flares.

When double flares are installed, the connection should be initially torqued to 100 inch-pounds. Where leaks cannot be stopped with 100 inch-pound torques, up to 200 inch-pounds may be used. Do not apply the maximum allowable torque at first, but tighten the fitting just enough to stop leakage. If the leak cannot be stopped with the prescribed maximum torque, the connection is faulty and must be replaced.

Thread compounds should not be used on flared tube-fitting threads. However, if the nut cannot be turned by hand so the flared tube fits snugly against the fitting, a compound may be used. In this event, apply a compound conforming to Specification MIL–C–5542. Apply the compound sparingly to the outer three threads of the male fitting. Never apply thread compound directly on the face of the nipple or the flare as this will destroy the metal-to-metal contact between flare and tubing which is necessary to produce the seal.

TYPES AND IDENTIFICATION.—For replacements, use AN flared tube fittings of aluminum alloy whenever possible. These can be identified by their blue color and the symbol "AN" stamped on their surface.

NOTE: In an emergency only, bronze fittings or specially treated steel or cast brass fittings (plated) may be used if AN aluminum alloy fittings are not available. Untreated steel or cast brass fittings SHALL NOT be used in oxygen systems.

Tapered Pipe Thread Connections

The threaded portion of a pipefitting is tapered, so that when it is tightened the part with the external thread (male) is forced into the internally threaded (female) part, thereby creating a seal.

Since it is not practical to machine pipe threads for perfect fit, a combination antiseize and sealing compound should be used when installing pipefittings. The compound should be applied sparingly to the first three threads of the male fitting. The compound should be applied perpendicular to the threads in order to insure that the compound fills the threads to the root.

Use extreme care in tightening pipefittings with thread compound on them. The compound makes it hard to feel how tight you are getting them. Overtightening causes distortion, splitting, and leaks. Pipe thread fittings of the ⅛-inch size should be torqued to at least 125 inch-pounds and not over 175 inch-pounds. Fittings of the ¼-inch size should be torqued to at least 200 inch-pounds and not over 300 inch-pounds. If torque wrenches are not available, tighten the ⅛-inch fittings with a wrench no longer than 8 inches.

IDENTIFICATION.—For replacement of pipefittings, use aluminum alloy fittings. They are identified by their blue color, by the symbol "AN" stamped on one side, and the size indication "1" (for ⅛ inch) or "2" for (¼ inch) stamped on the other side. The ¼-inch size was mentioned as an example only.

Cleaning

After the tubing is bent and the ends are flared ready for installation in the aircraft, clean the tubing and fittings thoroughly to remove all oil, grease, or foreign matter. The tubing and fittings should be cleaned by flushing and washing them with MIL–C–8638 (Aer) material. Dry thoroughly with a stream of clean, dried, water-pumped air, or by baking for one hour at 160° F. Lines, while in temporary storage, must be capped to prevent dirt and moisture from entering their apertures. If specification MIL–C–8638 (Aer) is not available, use methods A and B which follow.

1. METHOD A. Flush with naphtha conforming to Federal Specification TT–N–95. Blow clean and dry of all solvent with water-pumped air. Flush with anti-icing fluid conforming to Specification MIL–F–5566 or anhydrous ethyl alcohol. Rinse thoroughly with fresh water. Dry thoroughly with a stream of clean, dried, water-pumped air, or by heating at a temperature of 121° C. (250° F.) to 149° C. (300° F.) for a suitable period.
2. METHOD B. Flush with hot inhibited alkaline cleaner until free from oil and grease. Rinse thoroughly with fresh water. Dry thoroughly with a stream of clean, dried, water-pumped air, or by heating at a temperature of 121° C. (250° F.) to 149° C. (300° F.) for a suitable period.

Caution: Omission of any of the steps in methods A and B is dangerous. Before starting the procedure for cleaning, make sure that all materials are available to complete all of the steps.

QUIZ

1. All high-pressure tubing is seamless copper tubing and has an outside diameter of
   a. 5/16 inch
   b. 3/16 inch
   c. 7/16 inch
   d. 9/16 inch
2. Flexible high-pressure hose is a natural rubber-lined tube and is tested to withstand a surge pressure of
   a. 6,000 p. s. i.
   b. 2,000 p. s. i.
   c. 3,000 p. s. i.
   d. 4,000 p. s. i.

3. Arrows embossed on the outside of the body castings of high-pressure check valves point in the direction of the
    a. regulator
    b. oxygen flow
    c. oxygen line
    d. cylinder
4. High-pressure check valves are ordered in
    a. 3 styles
    b. 2 styles
    c. 5 styles
    d. 4 styles
5. The handwheel-type filler valve is made from a
    a. heavy brass casting
    b. light copper casting
    c. heavy aluminum casting
    d. light alloy casting
6. Paste flux generally used for most silver soldering melts at
    a. 600° F.
    b. 200° F.
    c. 800° F.
    d. 400° F.
7. The oxyacetylene flame for silver soldering should be neutral, but may have a/an
    a. equal excess of acetylene
    b. slight excess of acetylene
    c. no excess of acetylene
    d. heavy excess of acetylene
8. Oxygen check filler valves used in high-pressure systems operate on a maximum normal working pressure of
    a. 1,400 p. s. i.
    b. 1,800 p. s. i.
    c. 1,600 p. s. i.
    d. 1,700 p. s. i.
9. All high-pressure fittings are joined to high-pressure lines by
    a. steel soldering
    b. brass soldering
    c. iron soldering
    d. silver soldering
10. Copper tubing used in high-pressure systems will melt at
    a. 1,981° F.
    b. 1,762° F.
    c. 1,542° F.
    d. 1,472° F.

11. Oxygen is never mixed freely with any other commercial gas unless its flow is through a
    - a. specially designed system
    - b. system
    - c. tip of a torch
    - d. terminating system
12. All high-pressure tubing type N is pressure tested to not less than
    - a. 2,000 p. s. i.
    - b. 2,500 p. s. i.
    - c. 3,000 p. s. i.
    - d. 3,500 p. s. i.
13. High-pressure copper tubing in an aircraft before being reannealed is good for
    - a. 20 months
    - b. 16 months
    - c. 18 months
    - d. 12 months
14. The maximum life for all high-pressure tubing in an aircraft is
    - a. 12 months
    - b. 18 months
    - c. 24 months
    - d. 16 months
15. A marking band shall be located on each high-pressure tube segment every
    - a. 20 inches or less
    - b. 26 inches or less
    - c. 22 inches or less
    - d. 24 inches or less
16. All high-pressure oxygen fittings are made of
    - a. aluminum and copper
    - b. brass and bronze
    - c. brass and copper
    - d. aluminum and bronze
17. Flux is used in silver soldering oxygen tubing to remove
    - a. grease and oil
    - b. oxide films
    - c. plastic finish
    - d. preservative
18. There are how many styles of high-pressure check valves?
    - a. 4
    - b. 3
    - c. 5
    - d. 8

19. Handwheel-type filler valves are now being replaced in oxygen systems with
    a. cam lever valves
    b. line valves
    c. lighter weight valves
    d. needle nose valves

20. At the inlet, the pressure reducing valve will operate at a maximum pressure of
    a. 1,800 p. s. i.
    b. 3,000 p. s. i.
    c. 2,400 p. s. i.
    d. 2,000 p. s. i.

21. The safety relief valve of the pressure reducing valve will relieve accumulated pressure in the low-pressure portion of the valve body of
    a. 476 p. s. i.
    b. 600 p. s. i.
    c. 450 p. s. i.
    d. 500 p. s. i.

22. The amount of lap versus the metal thickness of small diameter tubing should be
    a. 1 to 2 times
    b. 3 to 4 times
    c. 4 to 6 times
    d. 6 to 8 times

23. If prepared flux is not available, a mixture of borax and boric acid can be used in a proportion of
    a. 12 to 1
    b. 10 to 4
    c. 2 to 1
    d. 12 to 4

24. High-pressure flexible hose may be drawn in lengths of
    a. 75 to 100 feet
    b. 25 to 30 feet
    c. 40 to 50 feet
    d. 10 to 12 feet

25. High-pressure flexible hose is natural rubber-lined tube protected by
    a. neoprene coated nylon
    b. fiber inpregnated with rubber
    c. braided aluminum
    d. interwoven steel strands

CHAPTER 5

AIRCRAFT OXYGEN SYSTEMS

IDENTIFICATION AND DESCRIPTION

The type A–1 high-pressure diluter-demand oxygen system consists of one or more high-pressure oxygen cylinders complete with automatic-opening valves, high-pressure tubing, check valves, filler connection, and fittings leading from the cylinder direct to one or more outlet connections for permanent attachment of diluter-demand regulators.

Generally when we speak of diluter-demand regulators we also include pressure types; therefore, do not be confused or attempt to draw too fine a line among the items representing a particular system. For example, the type regulator used can make a big difference in the altitude limits obtainable with an A–1 type oxygen system; still it is basically the same type system. Figure 5–1 illustrates the legend used for diagramming oxygen installations.

Figure 5–2 illustrates a diagram of the A–1 type oxygen installation using one cylinder (A) and two cylinders (B).

Type A–2 reduced-pressure diluter-demand oxygen systems consist of one or more high-pressure oxygen cylinders complete with automatic-opening valves, high-pressure tubing and fittings, line check valves, filler connection, pressure reducers, manifold, reduced-pressure distribution lines and fittings, and outlet connections for attachment of diluter-demand regulators at specified crew stations. The system is suitably fitted with high-pressure line check valves to present a minimum loss of oxygen if lines or cylinders are damaged. If two or more cylinders form a part of the installation, they are manifolded at high pressure. One permanently mounted

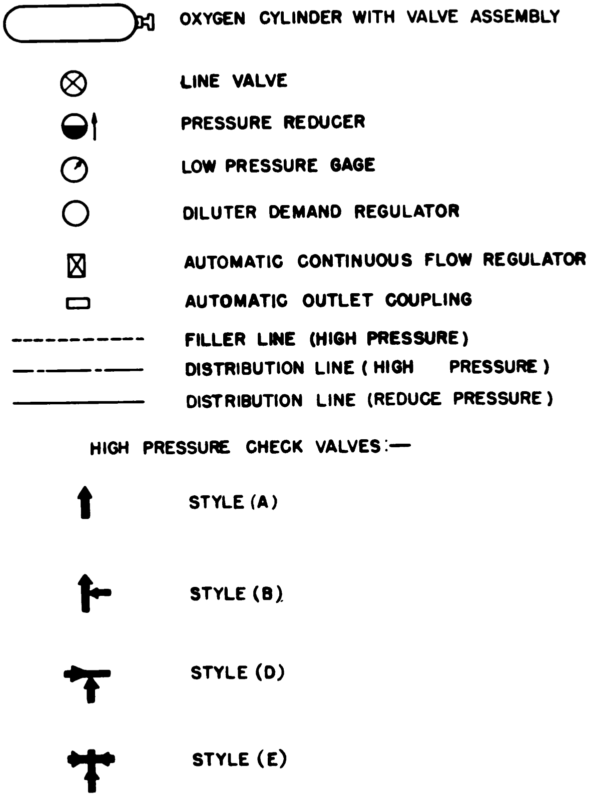

OXYGEN CYLINDER WITH VALVE ASSEMBLY
LINE VALVE
PRESSURE REDUCER
LOW PRESSURE GAGE
DILUTER DEMAND REGULATOR
AUTOMATIC CONTINUOUS FLOW REGULATOR
AUTOMATIC OUTLET COUPLING
FILLER LINE (HIGH PRESSURE)
DISTRIBUTION LINE (HIGH PRESSURE)
DISTRIBUTION LINE (REDUCE PRESSURE)
HIGH PRESSURE CHECK VALVES:—
STYLE (A)
STYLE (B)
STYLE (D)
STYLE (E)

Figure 5–1.—Legend for oxygen system installation.

pressure reducer is used with each group of cylinders. The number of pressure reducers is sufficient to assure that there is a minimum of one for every four persons using the oxygen supply. (See fig. 5–3.)

Type B continuous flow (C/F) oxygen systems for passengers consist of one or more high-pressure oxygen cylinders complete with automatic-opening valves, high-pressure tubing and fittings, line shutoff valve, line check valve, filler connection, manifold, pressure reducer, reduced-pressure distribution lines and fittings, automatic continuous flow regulators, and automatic outlet couplings at each passenger

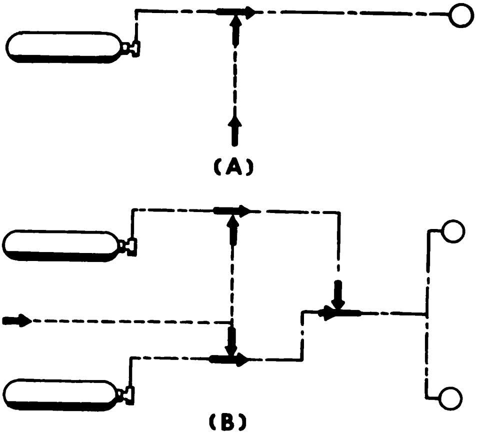


Figure 5-2.—Type A-1 oxygen installation. (A) One cylinder, (B) two cylinders.

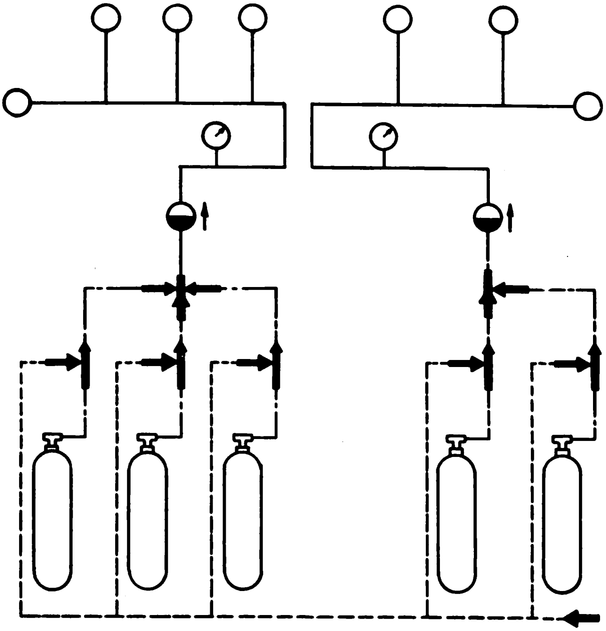


Figure 5-3.—Type A-2 oxygen installation with five cylinders.

station. The system is suitably fitted with high-pressure line check valves to present a minimum loss of oxygen if lines or cylinders are damaged. If two or more cylinders form a part of the installation, they are manifolded at high pressure. One permanently mounted pressure reducer is used for the entire system. The automatic C/F regulators are installed in parallel between the pressure reducer and the outlet couplings. (See fig. 5–4.)

Unless deleted by specifications, all new aircraft are equipped with quick-disconnect assemblies for use by pilots and aircrewmen. When practicable, the flexible tube assembly connected to the regulator outlet (diluter-demand type) is cut to 38 inches in length. Provision should be made for

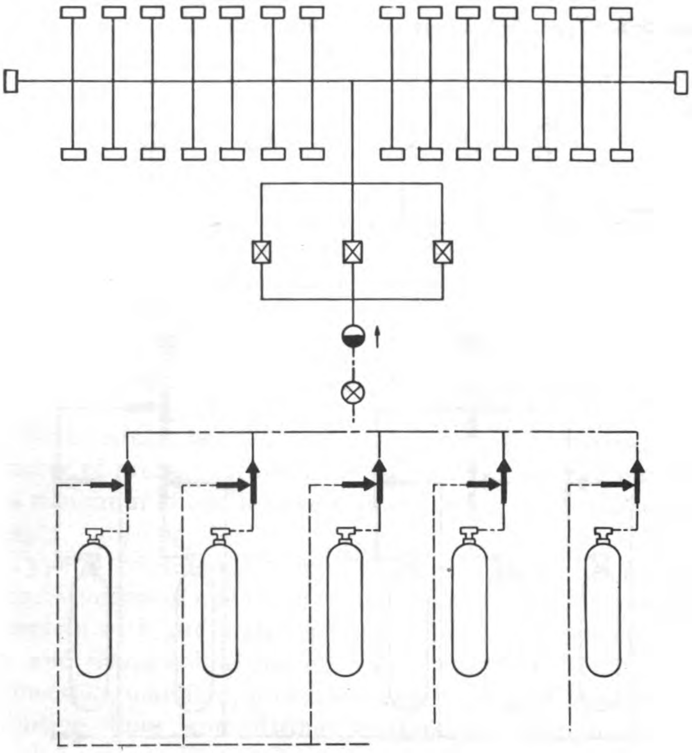


Figure 5–4.—Type B oxygen installation, continuous flow.

adequate storage of leads and flexible tubing in order to prevent damage when not in use.

In some aircraft, provisions have been made for the automatic opening of the oxygen bail-out supply during the operation of an ejection seat. The position of the emergency oxygen supply (bail-out unit) is determined by the type of ejection seat installed.

Working Pressures

The type A–1 high-pressure system is designed for a maximum working pressure of 1,800 p. s. i. Type A–2 reduced-pressure distribution system is designed for a working pressure of 1,800 p. s. i. in that part of the system between the supply cylinders and the pressure reducers, and from 50 to 75 p. s. i. for that part of the distribution system between the pressure reducer and the regulator. The type B distribution system is the same as the type A–2 system.

Using the symbols shown in figure 5–1, typical oxygen distribution systems for various types of aircraft have been shown in figures 5–2 through 5–4. These figures represent the general arrangement of the systems while the actual number, location, and application of the component parts are determined by the airplane's characteristics and are subject to approval by the Bureau of Aeronautics before installation. In type A–2 and type B installations where two or more cylinders are used, there is applied a minimum of tubing lengths in that part of the system between the cylinders and the pressure reducers. The general policy is to keep all tubing lengths to a minimum. Consideration is given to the integration of the oxygen system with other aircraft systems in such a manner that the fire hazard created by the proximity of combustible materials in the presence of oxygen will be at a minimum.

Specifications

(Permanent Systems)

The following items (from military specifications) are offered to familiarize Parachute Riggers with some of the important factors governing the design of oxygen systems. Many of the statements that follow answer some of the how's and why's of design.

Detail specification requirements are as follows:

1. The quantity and size of the oxygen cylinders are specified in the design specification for a particular model airplane involved.

2. The oxygen cylinders should be located in such a manner as to be readily accessible for removal and replacement. In combat aircraft, the cylinders are installed so as to be protected by existing armor from gunfire in accordance with BuAer Specifications. If this cannot be accomplished, the pilot should be shielded or protected from the effect of gunfire piercing the oxygen cylinder. They are so installed that any flash resulting from gunfire piercing the oxygen cylinder will not contact or injure personnel or essential equipment. Such protection is gunfire tested before a new model airplane system is accepted.

3. The oxygen cylinders should be installed so as to be chargeable, without removal, by use of a single high-pressure filler connection located to facilitate attachment of oxygen recharge equipment from outside the airplane.

4. Cylinder brackets in combat aircraft are designed to prevent the cylinder from tearing loose if they are hit by gunfire. Cylinders may be removed easily from the brackets for recharging or servicing.

5. Oxygen pressure reducers must be in accordance with the latest approved Navy Aeronautical Specification or shall be specifically approved by the Bureau of Aeronautics prior to installation in production. The pressure reducers are connected by high-pressure tubing and fittings to the oxygen supply in accordance with the general distribution system shown in figures 5–3 and 5–4. Pressure reducers, such as the Harris Model 41A, designed for direct attachment to oxygen cylinder valves, are mounted using an adapter which has been made in accordance with BuAer Drawing 1023–SK.

6. All tubing is mounted to prevent vibration and chafing. This is accomplished by the proper use of clips. The tubing at the clips, and where passing through or supported by the

airplane structure, must have adequate protection against chafing by the use of grommets and/or other suitable items or materials. All tubing must be banded in accordance with the latest applicable specification. The maximum length of unsupported tubing should be 24 inches for 3/16-inch O. D. (outside diameter) copper, and 36 inches for 1/8- or 5/16-inch O. D. aluminum alloy.

7. All aluminum alloy threads are treated with an anti-seize compound and all pipe threads are sealed with a thread sealing compound. The compounds must be made in accordance with Specification MIL–C–5542. Compounds shall be applied sparingly to male threads only and be used in accordance with the manufacturer's recommendations. Never clog the lines with an excessive amount of compound.

8. High-pressure fittings are attached to high-pressure copper tubing only by brazing with a suitable silver brazing alloy, such as the kind described in chapter 4.

9. When two or more cylinders comprise the oxygen source, they are manifolded at high pressure. Manifolding is the leading of the supply tubing from each cylinder through a check valve by the use of tees and crosses to distribution lines leading directly to the diluter-demand regulators (in A–1 systems) or to the pressure reducers (in A–2 and B systems). This is shown in figures 5–2 through 5–4. Cylinders are manifolded in groups of not more than three in type A–2 systems, each group being connected to one pressure reducer. An oxygen pressure gage, calibrated from 0–100 p. s. i. to indicate the working pressure in each type A–2 or type B reduced-pressure distribution system, is connected into the distribution line at or near each pressure reducer, and should be mounted where it can easily be seen by a crew member during flight.

10. Since line check valves direct the flow of oxygen, they are installed where they will be effective in preventing loss of oxygen from additional cylinders in the event of any oxygen cylinder being damaged by gunfire. Installation shall be made between the filler connection and each cylinder, and also between each cylinder and the point of manifolding as shown in figures 5–2, 5–3, and 5–4.

11. Outlet fittings are located in the oxygen supply lines of type A–2 systems, one at each crew station. These outlets are designed as tee fittings with the supply line outlet in accordance with Fitting Specification MIL–F–5509A–3 to allow for the connection of $\frac{5}{16}$-inch O. D. by 0.035-inch flared aluminum alloy tubing. The outlets must be suitable for connection to diluter-demand regulator inlets. Outlet couplings in accordance with AN6009 shall be located in the distribution lines of type B systems, one at each passenger station. Automatic couplings must be mounted in readily accessible locations so that it will be possible to connect the oxygen masks easily while in flight.

12. The oxygen filler connection is located at or near the outside of the airplane in order to facilitate charging operations from portable transfer apparatus within reach of ground level. An oxygen filler connection can be a line check valve with filter in accordance with MIL–V–8620 (Aer) and is capped in accordance with BuAer Drawing No. 1027–SK, using a solid cone and nut assembly attached by a short length of chain to the aircraft structure.

13. Aircraft with service ceilings above 35,000 feet are equipped with the automatic pressure breathing regulators while aircraft with lower service ceilings are equipped with the standard composite diluter-demand regulator with safety pressure. Diluter-demand regulators are mounted on suitable brackets and located where they can be easily seen and readily manipulated by the personnel whom they are intended to serve. The regulators are located on the pilot's left in a position forward of the power quadrant or an equivalent position. The controls of the regulator shall be accessible to the user for normal operation when the shoulder harness is locked and tight.

14. Adequate lighting should be provided for night operations. The regulator must be protected from the conditions following:

a. Slipstream or wind blast.

b. Rain and direct sunlight.

c. Dripping oil, grease, water, or other foreign matter.

d. Accidental damage by crew, mechanics, or equipment during normal operations and servicing.

e. Accidental operation of controls during normal flight operation.

15. Breathing tubes for use with diluter-demand regulators made of pure rubber are cloth bound and wire wound to prevent kinking. Breathing tubes are 1, 2, 3, 4, or 6 feet in length as required by the particiular airplane installation. Suitable spring clips are provided in the airplane to anchor breathing tubes while not in use, and a cloth or metal tab is installed on the airplane for attachment of the clamp on the mask connector. (See fig. 5–5.) The installation of the breathing tubes and the lengths chosen must be such that the user's movements will not be restricted during his normal duties at his station. Excessive lengths with resultant bulki-

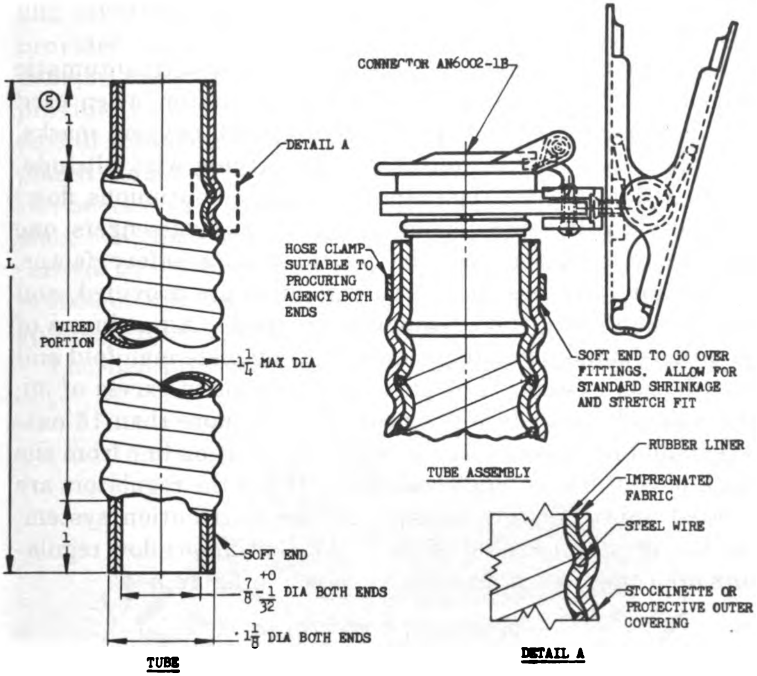

⑤
1
L
WIRED PORTION
1
DETAIL A
CONNECTOR AN6002-1B
HOSE CLAMP SUITABLE TO PROCURING AGENCY BOTH ENDS
$1\frac{1}{4}$ MAX DIA
SOFT END TO GO OVER FITTINGS. ALLOW FOR STANDARD SHRINKAGE AND STRETCH FIT
TUBE ASSEMBLY
RUBBER LINER
IMPREGNATED FABRIC
STEEL WIRE
STOCKINETTE OR PROTECTIVE OUTER COVERING
SOFT END
$\frac{7}{8}{}^{+0}_{-\frac{1}{32}}$ DIA BOTH ENDS
$1\frac{1}{8}$ DIA BOTH ENDS
TUBE
DETAIL A

Figure 5–5.—Tube assembly—oxygen mask to regulator.

ness and resistance to breathing is always avoided. If it is necessary to route the breathing tube around or behind equipment or a structure which would cause abuse of the flexible tube, aluminum alloy tubing of ¾-inch O. D. or larger may be used in that part where flexibility is not required.

16. Provisions are made to prevent loss of oxygen at pressure breathing altitudes from unmanned regulators in multiplace aircraft by use of regulators which have a manual shutoff valve incorporated. Where use of such a regulator is impracticable, a manual shutoff valve can be installed in the system in an accessible position, preferably close to the regulator.

17. Oxygen is conveyed to turrets through an oxygen swivel joint or flexible hose at a reduced pressure of type A–2 installations. When an oxygen swivel joint is required, or when a flexible hose is required, the task must be performed strictly in accordance with applicable specifications and drawings.

18. Type B passenger systems are provided with automatic continuous flow regulators. This type regulator, when used with AN6009 outlet couplings and A–8B oxygen masks, provides a continuous flow of oxygen varying with altitude.

19. Although each regulator (automatic continuous flow) can individually supply enough oxygen for 15 passengers, one additional regulator must be provided as a safety factor. Hence, for 15 or less users, two regulators are provided, and for 16 to 30 users, three regulators are used. A maximum of 30 outlets and 3 regulators comprise a complete manifold and distribution system. For passenger stations in excess of 30, the manifold procedure is repeated. Not more than 15 outlets should be connected to any one distribution line from the bank of continuous flow regulators. When the regulators are located approximately midway in the distribution system, the line must not exceed 50 feet. All continuous flow regulators are connected in parallel as shown in figure 5–4.

PORTABLE SYSTEMS

The individual portable oxygen systems are employed under the following conditions:

1. Used to supplement an adequate permanent type system when it is temporarily necessary for crew members to move about the aircraft, detaching themselves from the main system.
2. Used by crew members only where the pilot and copilot are equipped with a permanent type system of their own.
3. Used as the sole source of supply of oxygen where an aircraft is not equipped with a permanent type system.

High-Pressure Type

Figure 5–6 illustrates a high-pressure portable oxygen system. A 205- or 295-cubic inch capacity, 1,800 p. s. i., cylinder is secured in a suitable bracket equipped with an AN6004 series regulator which is connected to the cylinder with a short coiled length of copper tubing. A short flexible breathing tube, clamped to the outlet of the regulator at one end and fitted with an AN6002 type connector at the other end, provides the necessary assembly for the attachment of the demand mask tube. Straps fastened to the cylinder bracket provide the means for securing the unit to the user's seat or part of the aircraft's structure. The cylinder bracket may be placed horizontally or stood on end while in use. The straps can be used as a handle to facilitate carrying it from place to place. Because of its weight, the portable unit should not be carried by its breathing tube, regulator, or copper tubing. A 205-cubic inch capacity portable high-pressure unit weighs approximately 20 pounds 12 ounces.

The high-pressure portable unit is equipped with a pressure

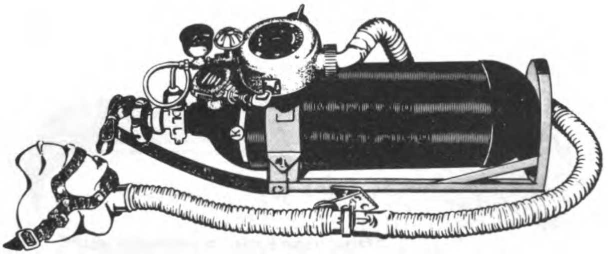


Figure 5–6.—A high-pressure portable system.

gage threaded into the regulator inlet, which affords the means of checking the remaining supply of oxygen in the cylinder. These units cannot be refilled from the aircraft's system, but must be serviced by portable and/or permanent type oxygen recharge equipment. This requires the loosening of the bracket and disconnecting the copper tubing at the cylinder valve, which is the handwheel type.

Low-Pressure Type

Low-pressure portable oxygen units, usually called "walk-around assemblies," consist of a special type of demand oxygen regulator directly attached to a small, lightweight supply cylinder. Portable demand regulators (low-pressure types) have a socket for direct connection with the mask tube. They also have a pressure gage, a clothing clamp, and a recharge adapter by means of which the cylinder may be refilled during flight.

The type A–1 portable unit is the standard diluter-demand portable unit used in conjunction with low-pressure systems. This portable unit consists of a type A–6 cylinder and a type A–15 diluter-demand regulator. It is the most convenient and economical of the various demand type portable units. When charged to 400 p. s. i., this unit will last about 30 minutes, assuming the user is only moderately active and at an altitude of about 25,000 feet.

Brackets for portable demand systems are provided at each crew station having a type A–1 unit. Other portable units similar to the A–1 require storage brackets suitable to their contours. Figure 5–7 illustrates the A–1 type portable unit.

When using low-pressure portable units during flight,

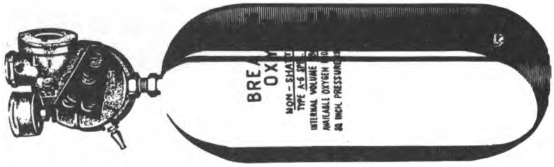


Figure 5–7.—Type A–1 portable oxygen unit.

and before leaving your station, inform the senior pilot of where you are going and what you intend to do. Look at the pressure gage on your portable regulator to see that the cylinder is charged. Clip the regulator to your clothing or suspend it from your shoulder (type A–1 is not equipped with a sling for this purpose). Hold your breath when disconnecting from the station supply and plug the mask tube fitting into the portable unit. ***Caution:*** Always check the pressure gage at frequent intervals when using any kind of low-pressure portable oxygen unit. When the pressure drops to 100 p. s. i., proceed to a recharge hose where the portable unit can be refilled.

To recharge or refill a portable unit, uncap the valve at the end of the portable recharger assembly, and plug in the recharge adapter (valve) that projects from the side of the portable regulator. A portable recharger assembly is usually found at each station where there might be a need for it. The user can continue to breath from the portable unit while it is being filled. To recharge a portable unit, push the male type valve into the recharging valve with considerable force, so that it clicks and locks itself into place. Watch the pressure gage on the portable regulator. The cylinder will be filled in a few moments, and the final pressure on this gage will then be the same as, or a little below, the pressure shown on the gage at that station.

EMERGENCY OXYGEN CYLINDER

H–2 Bail-Out Assembly

The emergency oxygen cylinder assembly is designed as an emergency source of oxygen for flying personnel operating at high altitudes. If the airplane's oxygen system fails and other supplementary oxygen sources are exhausted, the emergency assembly will afford a source of oxygen while the airplane is rapidly brought down to the altitude where supplementary oxygen no longer is needed. In the event of a parachute descent, its effectiveness depends on the user reaching a safe altitude in the shortest possible time.

Detailed description.—The 214A2 (Erie Manufacturing Co. part number) emergency oxygen assembly is composed

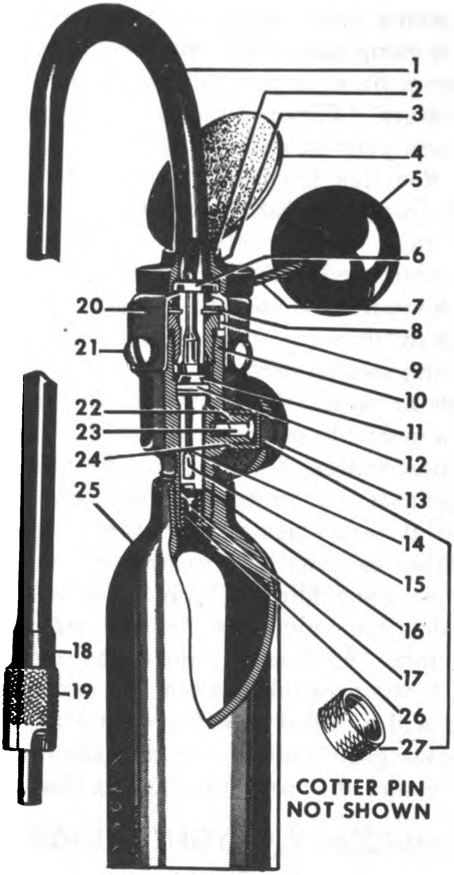


Figure 5–8.—Cutaway view—emergency oxygen cylinder.

1. Tube.
2. Housing, pull cable.
3. Pin.
4. Caution tag.
5. Ball.
6. Ring.
7. Cable.
8. Retaining ring.
9. Bushing.
10. Valve body.
11. Breakoff nipple.
12. O-ring.
13. Pressure gage.
14. Orifice body.
15. Metering element.
16. Porex filter.
17. Cap, flow controller.
18. Ferrule.
19. Connector, bayonet.
20. Housing base.
21. Screws.
22. Nipple, filling.
23. Porex filter.
24. Cap, dust.
25. Cylinder.
26. Spring.
27. Cap—removed during recharging.

of a cylinder, valve assembly, and valve-to-mask tube and connector assembly. The steel, shatter-proof, high-pressure oxygen cylinder has a nominal internal volume of 22 cubic inches. The pressure gage on the assembly should show at least 1,800 p. s. i. at a temperature of 77° F. before the user goes aloft. However, the cylinder should not be charged to a pressure exceeding 2,100 p. s. i. at 77° F.

The valve assembly which is attached to the cylinder with a tapered thread connection consists of various components shown in figure 5–8.

The pressure gage (13) indicates the oxygen pressure in the cylinder in pounds per square inch. It has no scale calibrations other than a black indicator mark from 1,800 p. s. i. to 1,900 p. s. i., a black scale arc above 1,900 p. s. i., and a red scale mark below 1,800 p. s. i. When the temperature of the emergency oxygen assembly is 25° C. (77° F.) and the gage pointer is above the 1,800 p. s. i. mark, the cylinder is sufficiently charged for safe operation. When the gage pointer is in the red segment of arc (at the same temperature), the cylinder content is insufficient for safe operation and should be recharged. The pressure gage is attached to the valve body (10) by means of a tapered thread connection.

The housing and pull cable assembly is attached to the valve body by means of four cadmium plated screws (21). This assembly is composed of a housing base (20), housing (2), pull cable (7), and ring (6) assembly, ball handle (5), binding screw which holds the cable in the ball, and a caution tag (4) and pin (3) assembly which prevents the cylinder (25) from being accidently discharged. When the caution tag assembly is removed, the equipment can be actuated by pulling the ball handle.

The valve assembly is composed of the following subassemblies and parts:

The valve body assembly comprises the valve body which encases the working parts. The filler connection (22) is soldered into the valve body making it an integral part thereof. The filler screen (23) is a powdered metal filter which is pressed into the filler connection.

The oxygen flow controller assembly consists of a controller assembly body (14), metering element (15), powdered metal dust filter (16), and cap (17). This assembly seals the oxygen cylinder assembly by forcing it against its seat and against the seat in the breakoff nipple (11) by screwing down the bushing (9). For filling purposes, it is raised from its seat in the valve body assembly by the spring (26) when the bushing is unscrewed. The oxygen flow controller assembly is calibrated to permit oxygen to be discharged at the proper rate.

The breakoff nipple assembly consists of two parts: Breakoff nipple and O-ring (12) used for sealing the assembly during the charging operation.

The bushing assembly consists of two parts: Bushing (9) and retaining ring (8). Screwing down the bushing, seals the valve assembly by seating it against the upper seal of the flow controller assembly, and forcing the flow controller assembly against its seat in the valve body assembly. The retaining ring serves to prevent the accidental slipping of the wrenches used in tightening with the likelihood of fracturing the breakoff nipple.

The tube and connector assembly consists of the rubber tube (1), the bayonet connector (19), and ferrule (18) for attaching the tube to the bayonet connector. The open end of the tube connects into the valve, while the bayonet connector attaches to a mating connector fitting in the oxygen mask connector assembly.

Principles of operation.—With caution tag and pin assembly removed, a straight-out pull force of approximately 20 pounds on the ball handle causes the ring encircling the rubber tube and the breakoff nipple to slide in the housing (2). This factures the end of the nipple at the groove machined into it and allows oxygen to flow from the cylinder (25). The oxygen enters the valve body (10) through the drilled hole at its lower end, then enters the drilled hole in the oxygen flow controller cap (17), passes through a powdered metal filter (16), flows through the metering element (15), through the drilled hole in breakoff nipple (11), and finally through the fracture in this part into the rubber tube (1). Since the check valve in the mask connector fitting is opened by the insertion of the bayonet connector (19), the oxygen thus enters the mask hose. The oxygen flow controller metering element (15) is so calibrated that oxygen is discharged by the cylinder in accordance with a flow curve. If the cylinder pressure is 1,800 p. s. i. before starting discharge and the temperature at the time is 25° C. (77° F.), the oxygen discharge will be 10 to 12 liters during the first minute and about 1 liter during the tenth minute of flow. A 10-minute period is considered the useful flow period for a cylinder charged to 1,800 p. s. i.

OPERATING INSTRUCTIONS.—The caution tag and pin assembly having been removed, the equipment can be actuated by pulling the ball handle in a straight-out direction. At normal temperatures, a force of approximately 20 pounds is sufficient to actuate the mechanism. At extremely low temperatures, a somewhat higher force is required. When the ball handle is pulled, the cable will not disengage from the cylinder as a parachute ripcord does (excepting the NB4 type), but will remain attached after operation.

When it becomes necessary to bail out, the emergency oxygen cylinder assembly should not be actuated until the last possible instant before leaving the airplane. In the case of fighter-type aircraft, the aircrew member should remain connected to the regular airplane oxygen supply while all other preparations for leaving the airplane are being made. When used as an emergency oxygen supply, the mask tube must be disconnected from the aircraft system before the emergency oxygen cylinder is actuated. The altitude should then be reduced to less than 20,000 feet within 10 minutes or sooner, continuing the descent to below 10,000 feet.

SERVICE INSPECTION.—The emergency oxygen cylinder assembly must be checked for completeness and general condition prior to each flight.

1. Check the pressure gage reading to see that it indicates at least 1,800 p. s. i. at normal temperature (approximately 25° C. (77° F.)). For deviations in indicated pressure, see

instructions outlined in chapter 2. If the cylinder pressure is below 1,800 p. s. i. at 25° C. (77° F.) temperature, the cylinder should be refilled before being taken on a flight.

2. Check the gage for cracked or broken cover glass, dented case, or other visible defects.

3. Inspect the pull cable housing to insure that is not deformed or in any way binding on the pull cable. Check the screws holding the housing for security. Check the pull cable ball to insure attachment to the cable. The screw should be tight.

4. Inspect the oxygen tubing to ascertain that it is free from cuts or deterioration, and that it is secured to the bayonet fitting assembly.

5. Be sure the caution tag (4) and pin assembly (3) have been removed before boarding an airplane for a flight.

MAINTENANCE.—After the emergency cylinder has been used or accidentally discharged, recharge it as soon as possible, and make it ready for service. The recharging operation will be described in chapter 7.

TYPICAL OXYGEN SYSTEMS

In order to make correct and proper repairs effectively, Parachute Riggers must make frequent references to the handbooks and catalogs concerned when engaged in detailed work on a particular airplane. These references are often supplemented by Change Bulletins and other guiding technical publications. The latest information is of the utmost importance to the personnel whose duty it is to service and repair aircraft oxygen systems.

Study figures 5–9 and 5–10 as being typical examples of high-pressure and reduced-high-pressure oxygen systems and portable walkaround cylinders.

From figure 5–10 we can see that the airplane is provided with a reduced-high-pressure demand oxygen system that supplies five diluter-demand regulators and breathing tubes for approximately 2 hours at 20,000 feet altitude, or for two regulators approximately 6.5 hours at 5,000 feet altitude (night operations). Four portable individual diluter-demand units are provided for walkaround use. The forward mask container, located behind the pilot's seat, and the aft mask container, located on the sidewall of the forward cargo door, have provisions for storing eight type A–13 oxygen masks.

Oxygen is supplied from three high-pressure cylinder-and-valve assemblies, through a manifold, to the high-pressure gage and the pressure reducer. A relief valve is plumbed into the system after the pressure reducer and oxygen is routed to a low-pressure gage and the five-crew diluter-demand regulators. The relief valve is connected to the overboard discharge tubing from the cylinders and discharging of oxygen is accomplished through an overboard fitting. The cylinders are charged from a filler assembly located forward of the crew door and access to the filler is through a door stenciled OXYGEN FILLER VALVE.

Three oxygen cylinders are clamped to the left sidewall behind the pilot's station. Each cylinder has a poppet-type shutoff valve and a retainer safety disk, including a fusible metal plug which melts at a temperature of 100° C. (212° F.) to discharge the cylinder overboard through a fitting located forward of the forward cabin door. Each cylinder has a 514-cubic inch capacity and may be charged to a pressure of 1,800 p. s. i. at 21° C. (70° F.). The weight of each fully-charged cylinder, less cap and washer, is 23.11 pounds maximum.

To remove or install an oxygen cylinder, close the oxygen cylinder handwheel valve. Depressurize the lines by opening the shutoff valve on any crew diluter-demand regulator and depressing the safety pressure mechanism until oxygen ceases to flow. Remove and immediately cap the oxygen supply and discharge lines from the cylinder. ***Caution:*** It is extremely important that oxygen lines be capped at all times while they are disconnected. In the event of a line remaining uncapped for any length of time, it should be degreased by some accepted method before being reinstalled in the system. (See chapter 4 for an approved method of cleaning oxygen lines.) Remove the clamps securing the cylinder to the sidewall and remove the cylinder

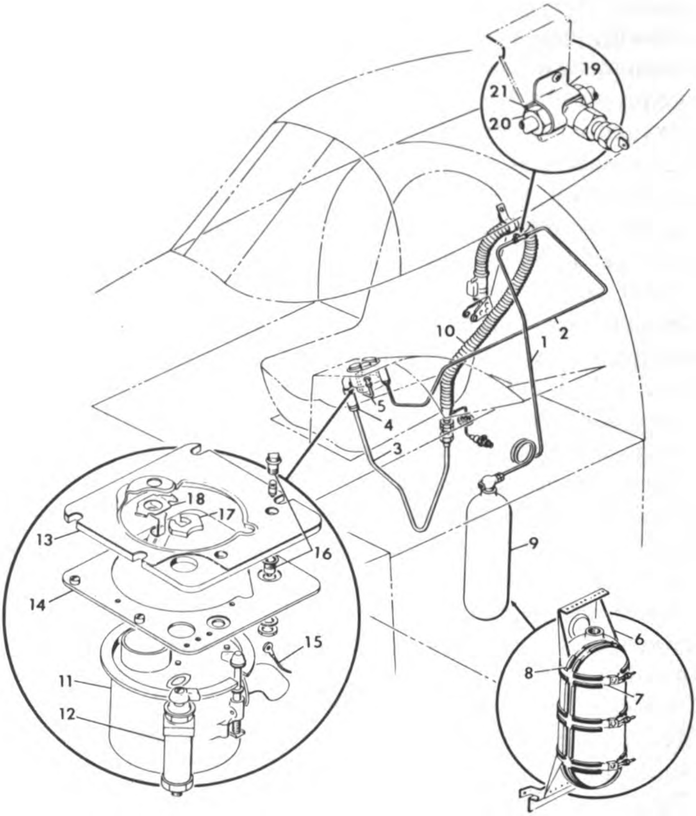


Figure 5–9.—High-pressure oxygen system.

from the mounting rack. The installation procedure is the reverse of the removal procedure.

The high-pressure gage (0 to 3,000 p. s. i.) is mounted on the left side above the main oxygen cylinder and indicates the pressure on the cylinder side. The low-pressure gage (0 to 200 p. s. i.) is mounted along side the high-pressure gage and indicates the system pressure.

The pressure reducer, mounted forward of the main oxygen cylinders, reduces the cylinder pressure (1,800 p. s. i.) to a working pressure of 65 (+0, −5) p. s. i. and a flow rating of 14.12 cubic feet (400 liters) per minute maximum.

Nomenclature for figure 5–9

1. **Tube assembly, oxygen cylinder to filler valve.**
2. **Tube assembly, oxygen filler valve to shutoff valve.**
3. **Tube assembly, oxygen regulator outlet to receptacle.**
4. **Hose, oxygen line.**
5. **Tube assembly, oxygen register to shutoff valve from upper demand valve diluter to remote flow indicator.**
6. **Bracket assembly, oxygen cylinder.**
7. **Bracket assembly, strap and clamp.**
8. **Pad, oxygen cylinder bracket valve end.**
9. **Cylinder assembly, automatic-opening valve and cylinder.**
10. **Disconnect assembly, breathing extension tube (sometimes combined with antiblackout suit connector and electrical leads). A breathing extension tube and an electrical microphone—headset lead are the only components shown in the figure.**
11. **Regulator, oxygen.**
12. **Valve, oxygen shutoff.**
13. **Cover assembly, oxygen regulator and shutoff valve.**
14. **Support assembly, oxygen regulator and shutoff valve.**
15. **Cable electric, oxygen regulator and shutoff valve.**
16. **Light, plastic plate lighting panel.**
17. **Lens, oxygen regulator pressure gage lighting.**
18. **Clip assembly, oxygen regulator pressure gage lighting lens.**
19. **Brackets, oxygen filler valve.**
20. **Valve, oxygen filler and check.**
21. **Pad, oxygen valve protection.**

The relief valve, mounted forward of the main cylinders and located in the system after the pressure reducer, cracks at 100 (±5) p. s. i. and reseats at 80 p. s. i. minimum.

Diluter-demand regulators are described in chapter 2. For the removal and installation of a diluter-demand regulator, close the cylinder handwheel valve on each cylinder. Depressurize the lines until oxygen ceases to flow. Disconnect the breathing tube from the regulator outlet. Disconnect the supply line at the regulator. Access to the navigator's supply line is behind a cover on the aft side of the regulator. Remove the four screws holding the regulator to the mounting and remove the regulator. To remove the navigator's regulator, remove eight screws on the mounting assembly, then remove the four screws holding the regulator to the mounting. Installation is the reverse of the removal procedure.

System leaks are kept to a minimum by the use of double-lap tubing on all aluminum tubing so that higher wrench torque valves may be used during assembly without failure. The recommended wrench torque for aluminum tubing ($5/16$-inch O. D.) is not to exceed a final tightening of 200 inch-

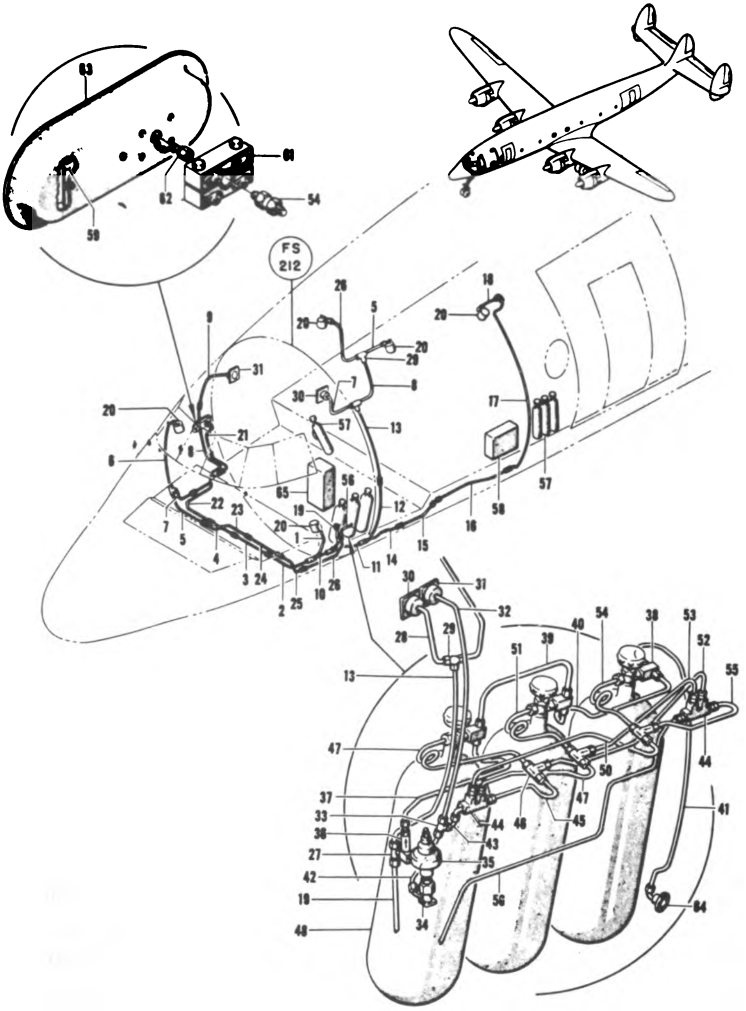


Figure 5–10.—Reduced-high-pressure oxygen system and portable walk-around cylinders.

Nomenclature for figure 5–10.

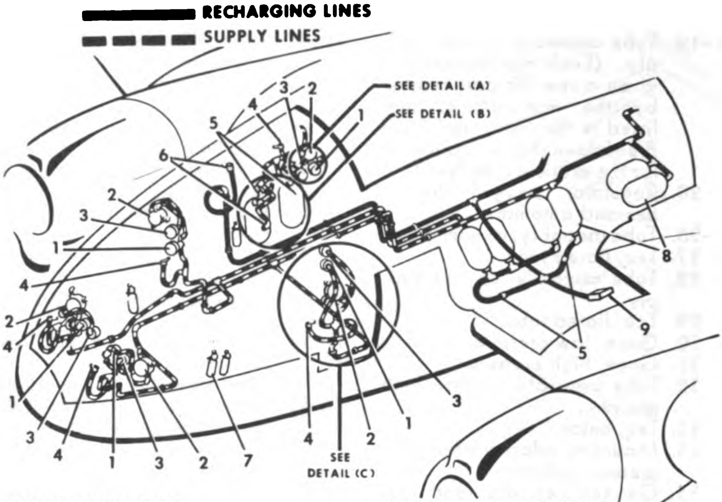
1–19. Tube assembly, oxygen supply. (Each tube assembly is given a specific part number by the manufacturer and listed in the *Illustrated Parts Breakdown* that is applicable for the particular system.)
20. Regulator, oxygen diluter-demand automatic.
21–26. Tube assembly, oxygen filler.
27. Tee, flared tube.
28. Tube assembly, oxygen supply.
29. Tee, flared tube.
30. Gage, low pressure.
31. Gage, high pressure.
32. Tube assembly, oxygen high pressure.
33. Tee, union.
34. Mounting adapter assembly, pressure reducer.
35. Oxygen regulator and cap assembly (pressure reducer).
36. Valve assembly, relief (oxygen). (Lockheed Specification.)
37. Tube assembly, overboard discharge oxygen. Notice how this entire assembly is manifolded to terminate through tube assembly number 41.
38. Tee-oxygen overboard discharge oxygen.
39–41. Tube assembly, overboard discharge oxygen.
42–43. Tube assembly, oxygen high pressure.
44. Manifold, oxygen cylinder distribution.
45. Tube assembly, oxygen high pressure.
46. Valve-high pressure oxygen check, style B.
47. Tube assembly, oxygen high pressure.
48. Cylinder, oxygen high pressure.
49–55. Tube assembly, oxygen high pressure.
56. Tube assembly, oxygen filler.
57. Oxygen unit, portable individual diluter demand.
58. Mask box assembly, A–13 oxygen mask.
59. Nameplate installation, oxygen system.
60. Valve, high pressure oxygen, style A.
61. Block assembly, high pressure oxygen filler valve mounting.
62. Cap assembly, oxygen filler valve.
63. Filler box, high pressure oxygen.
64. Indicator, flush type. (Lockheed Specification.)
65. Mask box assembly, oxyen.

pounds for nonlubricated threads. The recommended wrench torque for silver soldered (copper) tubing (3/16-inch O. D.) ranges from 25 to 30 inch-pounds, for nonlubricated threads. If leakage is detected, it is permissible to tighten these fittings after installation to an absolute maximum of 40 inch-pounds.

Figure 5–11 and 5–12 illustrate low-pressure systems.

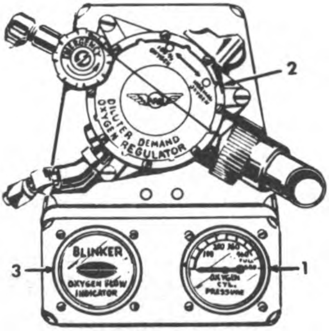
Figure 5–13 illustrates the flow path of oxygen through a series of automatic continuous flow regulators.

A type B system uses high-pressure cylinders and one or more pressure reducers to accomplish the same purpose as the all-low-pressure system utilizing continuous flow regu-



1 TYPE K-1 PRESSURE GAGE
2 TYPE A-12 OXYGEN REGULATOR
3 TYPE A-3 FLOW INDICATOR
4 PORTABLE UNIT RECHARGING CONNECTION
5 CHECK VALVE
6 RECHARGING LINE CONNECTIONS
7 TYPE A-6 PORTABLE OXYGEN UNIT
8 TYPE G-1 OXYGEN CYLINDER
9 FILLER VALVE

Figure 5–11.—Low-pressure oxygen system using demand type regulators.



DETAIL (A)

Figure 5–11.—Low-pressure oxygen system using demand type regulators—Continued.

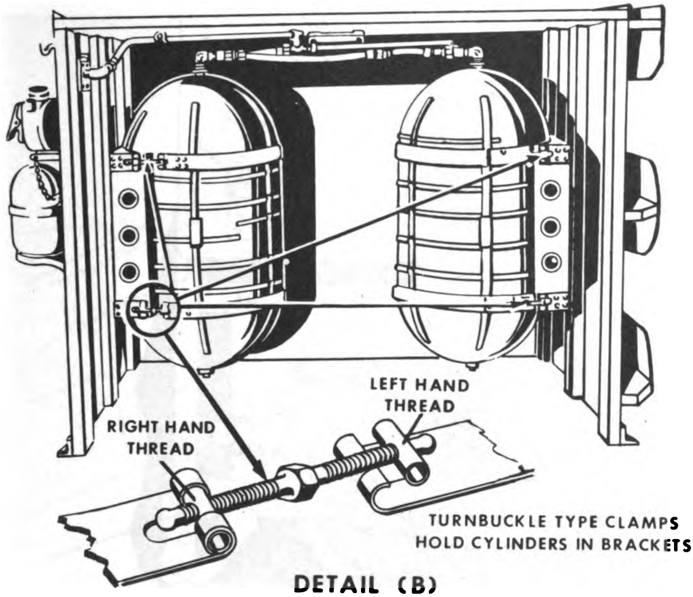
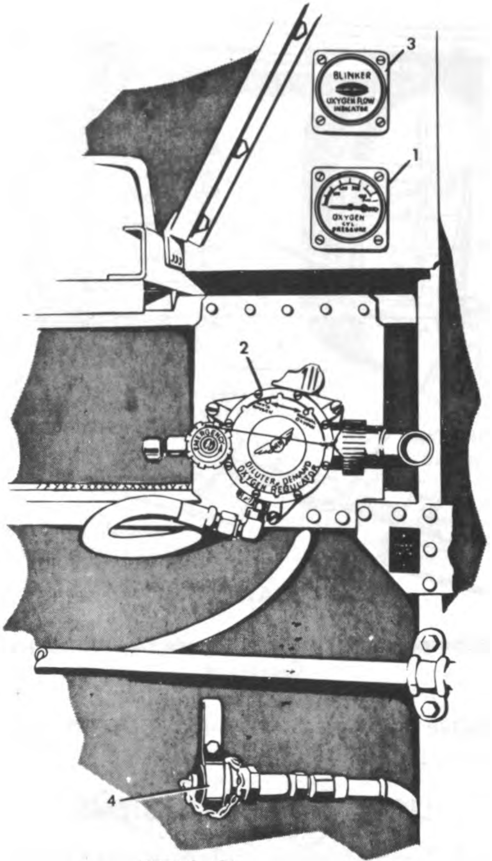


Figure 5-11.—Low-pressure oxygen system using demand type regulators—Continued.

lators. Because of the similarity of the two, a typical type B system will not be illustrated.

LIQUID OXYGEN SYSTEMS

The aircraft liquid oxygen system is similar to a gaseous low-pressure system except that the several cylinders of gaseous oxygen are replaced by a single liquid oxygen container known as a CONVERTER. The system contains the converter with associated valves, fittings, and filler connection, low-pressure tubing and fittings, and an oxygen regulator. The advantage of this system lies in the fact that liquid oxygen is a very concentrated form of gaseous oxygen. It evaporates into gaseous oxygen at a ratio of approximately 850 times its own volume. Also, it is retained at low pressures (normal operating pressures are 70 ± 10 p. s. i.), and therefore the container is constructed of light materials. This permits a great reduction in the weight of a liquid ox-



DETAIL (C)

Figure 5–11.—Low-pressure oxygen system using demand type regulators—Continued.

ygen system as compared to a gaseous system while the amount of available oxygen is doubled.

However, the aircraft liquid oxygen system does have some disadvantages. Because of its low temperature, liquid oxygen must be placed in special containers. The containers are specially insulated to maintain the low temperature required to keep the oxygen in a liquid state. Also, as there is continuous evaporation taking place, these containers must be vented to prevent a pressure buildup. This also means that

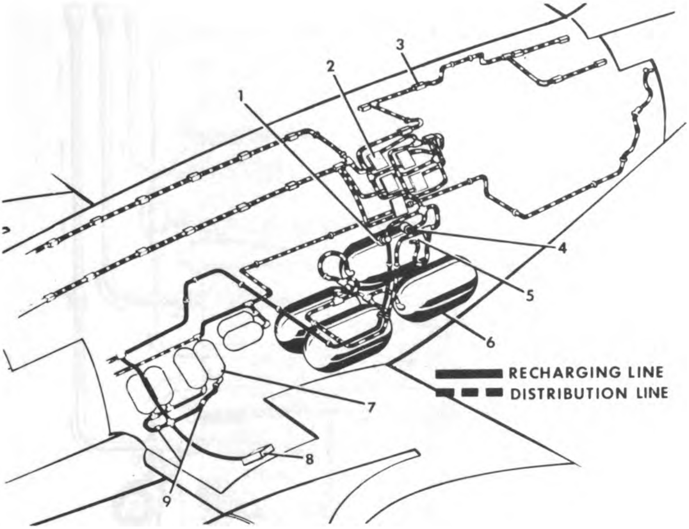


Figure 5–12.—Low-pressure oxygen system using continuous flow regulators.

1. Line valve.
2. Regulators.
3. Passenger oxygen outlets.
4. Pressure gage.
5. Portable recharger.
6. Type J–1 cylinders.
7. Type G–1 cylinders.
8. Filler valve.
9. Check valve.

after a certain period all of the liquid oxygen will evaporate and be lost.

As the aircraft liquid oxygen system is similar to the low-pressure system, with the exception of the container, only that part of the system will be explained here. The converter is in itself a system which contains the flask, evaporation coils, and several valves.

The liquid oxygen container with its accessories converts the liquid oxygen into warm usable gaseous oxygen. The converters are made in several sizes—5-, 8-, and 25-liter sizes being the most commonly used. Two sizes are illustrated in figures 5–14 and 5–15. The 5-liter size is used in single-place fighter type aircraft and the larger sizes in multiplace aircraft.

Converters may also be grouped by types according to the relative operating pressures and amount of oxygen they will

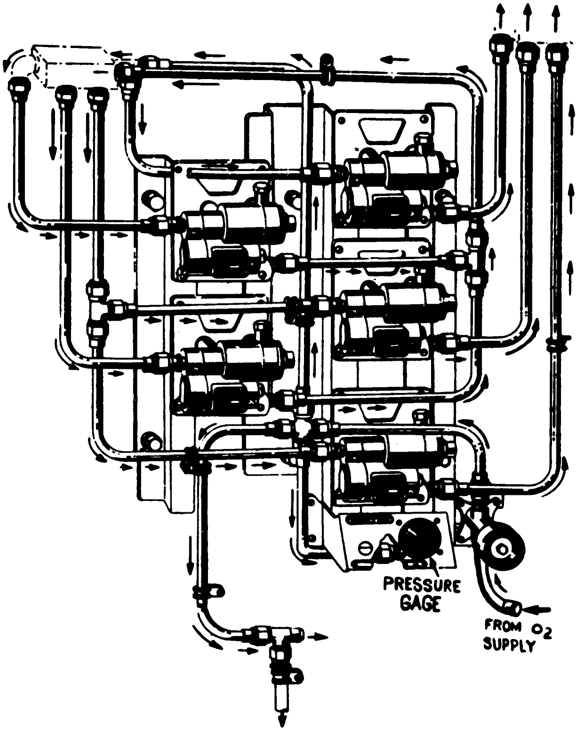


Figure 5–13.—Panel mounting of continuous flow regulators. Note that this panel arrangement is not manifolded identically as the one shown in figure 5–12.

deliver. There are two types used in naval aircraft: low-pressure, low-flow, and low-pressure, high-flow.

It is known that a man must have about 20 liters of oxygen per minute to survive; therefore, a converter must deliver that much warm gas for each user. Any converter that will deliver only 20 liters per minute of warm gas is a low flow converter. One that will deliver more, in multiples of 20, up to 120 liters per minute is a high flow converter.

Converters are also classified as high or low pressure, depending on the operating pressure of the system. In a low-pressure converter, the operating pressure is 70 p. s. i. In some Air Force aircraft, high-pressure converters with

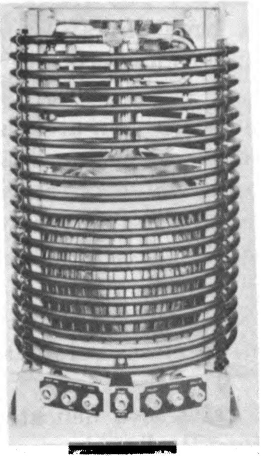


Figure 5-14.—8-liter converter.

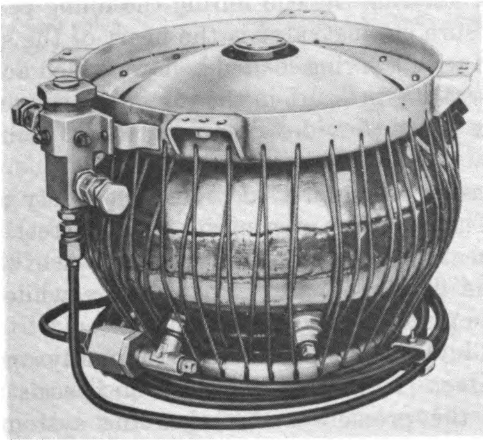


Figure 5-15.—5-liter converter.

operating pressure of 300 or 350 p. s. i., depending upon the manufacturer, are used. The reason for a high-pressure system is that on a large aircraft it will enable the crew members to fill a standard low-pressure walkaround cylinder from the system.

The valves used in the system are designed to control the evaporation rate and the operating pressure. These valves are the pressure closing valve, pressure relief valve, liquid check valve, and the buildup and vent valve. There is also a special filler valve. The operation and function of each valve is as follows:

The filler valve is open only when mated with the adapter on the transfer hose. It closes automatically when the hose is disconnected.

The liquid check valve is a delicate, pressure operated, check valve that meters the liquid oxygen to the evaporating coil. This valve is necessary to conserve liquid oxygen and to prevent any excessive pressure buildup. A secondary function of this valve is to prevent an excessive amount of liquid from entering the coil during the filling process.

The pressure closing valve is the heart of the system. It is equipped with a spring-loaded bellows which acts to maintain the operating pressure in the top of the converter. The body of the valve provides fittings for other components of the system.

Two pressure relief valves compose the safety units of the system. They consist of a spring-loaded steel ball which rests on a seat in the body of the valve. One of these valves protects the flask from excessive pressure while the other protects the plumbing of the system.

The buildup and vent valve is a manually operated two position valve. In the buildup position it seals the system to confine the pressure and makes the system operable. When on the vent position, it allows the pressure to be vented to the atmosphere to prevent any excessive pressure buildup in the system.

Operation of the system depends upon the characteristics of liquid oxygen. When the buildup and vent valves are placed in the buildup position (fig. 5–16), the continuous

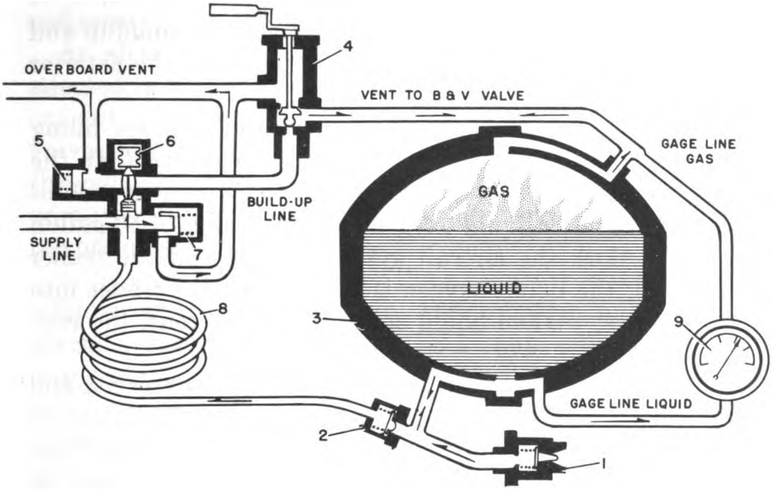


Figure 5–16.—Typical 5-liter liquid oxygen converter.

1. **Filler valve.**
2. **Check valve.**
3. **Liquid oxygen container.**
4. **Buildup and vent valve.**
5. **Container press relief.**
6. **Pressure closing valve.**
7. **Evaporator pressure relief valve.**
8. **Evaporating coil.**
9. **Liquid contents gage.**

evaporation of the liquid starts to build up pressure in the top of the converter. This pressure on the top of the liquid forces a small amount past the liquid check valve into the evaporating coil where it immediately turns to gas. As the gas expands, it flows into the pressure closing valve, the buildup and vent valve, and back into the top of the converter to continue the cycle. Pressure will build up in this manner until operating pressure is reached, at which time the pressure acting on the spring-loaded bellows compresses the bellows to a point where the valve (pressure closing) attached to the bellows closes and prevents any further buildup in the top of the converter. Oxygen to the regulator and to the user is supplied from the coil and any pressure drop in the coil causes more liquid to be metered past the liquid check valve to continue the supply.

The system is mounted in the aircraft in a readily accessible compartment outside of any pressurized area. The quantity gage and regulator must be mounted within sight and reach of the user. The filler valve and the buildup and vent valve are installed in a separate panel on the exterior of the aircraft.

Line maintenance of an aircraft system includes filling with liquid and the ground-crew check to insure that the system functions properly. Filling the converter is accomplished by use of a liquid oxygen transfer trailer of 50-gallon capacity. With the aircraft system vented and the trailer pressurized, the liquid oxygen is forced from the trailer into the converter. When liquid spills out of the vent, the converter is full.

During filling, the liquid capacity should be observed and the oxygen transfer should be stopped in sufficient time (if possible) to prevent liquid being spilled from the bent line. Filling should be done in a well-ventilated or open area so that if liquid oxygen is spilled, it will vaporize and be dissipated as rapidly as possible.

(The publications of some manufacturers advocate spilling liquid out the vent. They claim this is the only reliable way to be certain the system is full.)

The ground-crew check includes leak testing the lines, checking the buildup time of the converter, and proper operation of the oxygen regulator.

GROUND-CREW CHECK

The greatest part of the ground-crew check has been described in chapter 2, since the regulator is the controlling instrument concerned in the test. Periodically, system leakages occur in tubing connections and in other parts of the system. However, few leaks are so obvious that they can be located by a distinct hissing noise. To check for system leakage, turn on the gas pressure, admitting it into the regulator. Without actuating the regulator turn off the cylinder valve and observe the gage for dropping pressure. In systems employing automatic cylinder valves, the normal procedure for a system leakage check is different. In any case always make certain that the pressure is admitted fully into the regulator by opening the cutoff valves. The pressure gage or gages could not register if these valves were not open.

An alternate test source for overall leakage may be substituted in lieu of that described in chapter 2. The end or ends of tubing connected to cylinders fitted with automatic valves can be capped and the initial pressure obtained through the filler connection. With the pressure being admitted through the filler line connection, the following factors must be considered:

1. The cap employed over the end of the automatic nose adapter which is secured by the coupling nut, must be specially made in a local machine shop. When threaded into the coupling nut and tightened, it shall be capable of holding pressure up to 1,800 p. s. i. Once such a cap is made, it must be pressure tested with a soap solution or underwater before using it.
2. After using the filler connection, always check its security by applying a soap solution over the open end of the valve to ascertain that the check is working properly. Always cap the end of a filler connection.
3. After disengaging the end-of-line cap and connection is made with the automatic cylinder, apply a soap solution around the cylinder valve connection.
4. This type check is designed to expedite the time necessary that would ordinarily be taken up over a 24-hour period for the automatic system. While this method is reliable enough, do not fail to use the ultimate check of observing the system over a 24-hour period, whenever possible.
5. At least 1,500 p. s. i. must be used in the system whenever ground-crew checking an aircraft; a lesser pressure would not be reliable.

Type B systems involving the continuous flow regulators cannot be tested for operation at ground level since the regulator does not deliver oxygen at altitudes below 5,000 feet. In order to test a type B system for security, not operation, the automatic continuous regulators would have to be bypassed, using a specially made length of tubing to affect the connections. The distribution lines would remain under 60 to 65 p. s. i. throughout the test.

When inspecting an oxygen system use the utmost care. The following points shall be particularly noted and checked to insure that only complete, operational, and safe oxygen systems are accepted following the inspection and acceptance of a new aircraft:

1. Shipping plugs, caps, seals, tape, or other closing or fastening devices shall be removed from oxygen equipment before test and/or acceptance.
2. The breathing tube shall be firmly clamped onto the outlet elbow of the diluter-demand regulators, and elbows shall be tightened in the proper position, that position offering a lead without kinks or sharp bends.
3. Check to see that the instruments have been installed in a manner not to be damaged by movement of the crew or mechanics, or by the storage of cargo or other equipment around them.
4. Tieing down any part of an item, such as the air valve lever or emergency valve knob on nonpressure regulators with wire or tape, shall not be tolerated.
5. The breathing tubes must be properly clamped or clipped in position to permit immediate use, and to keep them out of the way when not in use.
6. The filler and distribution line shall be properly marked for identification purposes.
7. Antiseize and sealing compounds SHALL BE SPARINGLY APPLIED to fitting threads so that the compound WILL NOT BE ABLE TO ENTER THE SYSTEM OR TO FLOW OVER THE FITTINGS. ONLY COMPOUNDS SPECIFICALLY APPROVED SHALL BE USED.
8. When oil or grease sources are detected which are likely to drip on or near oxygen lines and equipment, deflector plates to keep oil or hydraulic fluids away from the system shall be used if necessary.
9. All oxygen regulators and indicating instruments are delicate aircraft instruments and shall be handled as such.

TROUBLESHOOTING

After performing the ground-crew check and the pressure drop is found to be excessive (all connections are tight) turn off the oxygen supply and remove the regulator. Attach a pressure gage to the end of the system line where it connects into the regulator. Turn on the oxygen supply, performing the system leakage test again. If no leak is apparent in the system, bench test the oxygen regulator.

To expedite the time needed to conduct a system leakage test, a manual cylinder can be connected to a system employing an antomatic cylinder at the first fitting away from the end of the tubing. This fitting can be a check valve or a tee union which is adaptable to a manual cylinder valve line connection.

A small portable manual oxygen cylinder can be used directly on a series of check valves in order to determine their pressure holding characteristics. With a portable cylinder, any connection can be tapped and the security of the connection and/or check valve be tested with an application of a pure soap solution. By this gradual process of elimination (making and remaking connections), it is possible to determine how certain check valves are working, which ones are checking, and which are not. Sometimes a check valve is installed in the system backwards. When this occurs, one cylinder in a series might be made inoperative because a check valve is admitting the oxygen into the cylinder but prevents its reentering the system. There are dozens of different possibilities; study any system employing more than one cylinder and you will be able to visualize them for yourself.

To check the pressure gage for malfunctioning, attach a charging line from a portable recharge trailer to the filler valve at the aircraft, and fully charge the system. Compare the pressure gage readings. The one in the aircraft must agree with the one on the trailer. The gage on the trailer must be calibrated periodically to assure its accuracy.

When the remote flow indicator fails to work, disconnect its line from the regulator. After removing the remote flow indicator, attach an oxygen supply using a portable cylinder outfit. Turn on the pressure and ascertain if the line is obstructed by feeling for the oxygen flow at the opposite end of the tube. If the flow indicator still fails to function properly after it has been reengaged, and the distance it is mounted away from the regulator is not too great (more than 10 feet), the instrument is defective.

Periodically check all system connections by applying a pure castile soap solution. The solution should be thick enough to adhere to the external contours of the fittings. This means that the soap solution is best when it has the same relative consistency as castor oil. Do not jump to conclusions by the observance of a few bubbles in the soap solution after it has been applied with a small paintbrush. The bubbles may have been formed by the application of the solution. The better the solution the fewer the bubbles on application. In order to apply a continuous film of soap solution around a fitting without a great number of misleading bubbles, one must have the solution at the right consistency, and not make too many brushing motions. At any rate, observe all bubbles carefully, pushing them aside from time to time to see if new ones will form in the place where the old ones were. Very small fittings or connections are sometimes harder to spot. When finished, always remove every trace of soap, leaving the connection clean and dry.

While engaged in painting soap around connections, there is not better time to examine the tubing for evidence of cracking or any other damaging effects. Overtorquing a connection will in time tend to split the body of a fitting. This is especially true of check valves. The simplicity of this job can lead one into carelessness, but when the individual making this check realizes how much depends on it, he would find it extremely difficult not to make anything but a thorough inspection.

MAINTENANCE.—Most of the problems concerned with maintaining any oxygen system can be, for the most part, summed up under preventive maintenance. Preventive maintenance involves a scheduling of reliable inspections designed to intercept the trouble before it starts.

The following is a general list involving problems of maintenance other than prevention:

1. Whenever working around an oxygen system, carry a

kit of tools with a set of open-end, socket, and box-end wrenches, capable of handling all the coupling nut sizes and other fittings necessary for a complete servicing of the system. The most popular size wrench used on a high-pressure system is a 7/16-inch open-end type. The box-end wrench being enclosed in a ring of steel cannot be slipped over tubing, and therefore its use is more limited. However, in certain instances where the working space is a problem, a small box-end wrench can be modified into a tube type wrench by cutting a slot slightly larger than the width of the tubing (3/16-inch) in the ring. A box-end wrench has many more points on which a coupling nut can be turned than the open-end type, which is a big factor in its favor. Other size wrenches, especially the larger sizes, may have to be shortened.

2. When starting a coupling nut or any other type nut, take care not to cross thread the connection. A cross threaded connection, needless to say, is a weakened one. It is one which cannot be accepted in a high- or low-pressure system. The only way to effectively repair a cross thread member is to remove it. On high- and low-pressure tubing this can mean the removal of an entire line. In emergencies the cone unions on the ends of copper tubing can be sweated off, and a new coupling nut slipped on, and the cone union silver soldered back in place. To perform this operational maintenance, the copper line must be removed from the aircraft. An aluminum line, being flared at both ends, poses a similar problem. It need not be heated to remove the coupling nut, but it has to be cut off, thus shortening the tubing. Shortening the tubing, even on long lines usually means it will be too short to be pulled back into place without overstraining it. Whenever starting a connection, turn the nut using the fingers for the first three or four threads, more if possible. Always finish tightening any oxygen fitting with a wrench, since it could not hold pressure otherwise. The same precaution holds true for screws and other types of threaded members.

3. The most popular size mounting screws used to install oxygen system instruments are the roundhead 8–32 and

10–32 sizes. Do not mutilate screwheads. When working with screws, select a proper size screwdriver whose blade will fit snugly in the head slot of the screw. The Phillips and Reed and Prince head type screws offer more turning surface because of their multipoint recessed head design. The recessed pattern varies with the design and the size of the screw.

4. The composition of the material encased in anchor nuts makes the first threading difficult to turn. Before attempting a back-of-panel mounting on a new instrument, "run-in" each anchor nut attached to it with a brass or steel screw. The first "run-in" exercise will speed up the time it takes to install an instrument which might be mounted in a confined area, and prevents mutilation of the screws most difficult to reach. An anchor nut or plate nut is a type of stop nut which is riveted to an instrument or an aircraft structural member. It is designed to eliminate the need for holding the nut while a screw is being threaded into it.

5. ANYTHING DISCONNECTED MUST BE RECONNECTED. Numerous near-accidents and accidents have happened because some careless person failed to reconnect certain mechanical linkages.

6. Some regulator installations are difficult to reach. It often requires 30 minutes or more to remove one and twice as long to reinstall. Many aircraft designs by virtue of their compactness make the removal of oxygen cylinders difficult. Every Parachute Rigger must become proficient in removing and reinstalling equipment. He must be especially adept at removing those items which require periodic testing, such as a regulator. In order to work efficiently, one must first be familiar with the system. Screws, nuts, plates, and fittings that go together to make up a system usually require a specific pattern for their assembly and reassembly. When removing a regulator, do not disconnect anything more than is necessary. Reassemble parts in their proper sequence or else you may have to disconnect a lead or plate already assembled.

7. Parts, such as drilled-head bolts, fillister-head screws, thumbscrews, plugs, and the like, are safety wired with

zinc coated soft steel wire. The size of safety wire used for bolts, screws, and plugs is determined by the size of the safety wire hole. Approximately 75 percent of the hole should be filled by the wire. The wire is generally applied by twisting and should be substantial. (See fig. 5–17.) The twisting may be done by hand with the exception of the final few twists which are done with pliers in order to apply more tension and secure the ends of the wire properly. Never overstress safety wire; it will break. Many aircraft cylinder brackets are secured around the cylinders and are held by thumbscrews which must be safety wired to prevent them from backing off. All cylinders, especially aircraft cylinders, must be held securely in their brackets. By applying the principles illustrated in figure 5–17, security can be maintained. SAFETY WIRE ALL PLUGGED CONNECTIONS.

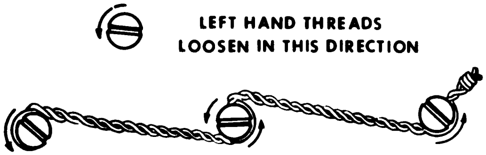


Figure 5–17.—Safety wiring.

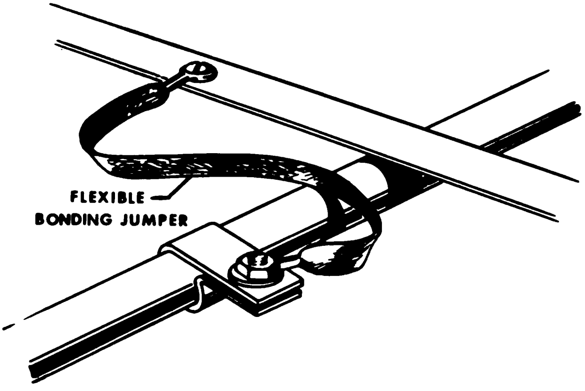


Figure 5–18.—Connection of a jumper to tubing.

8. The process of interconnecting electrically isolated metal parts of the airplane by means of good electrical conductors, including the connection of shielding to the airplane structure, is known as bonding. Bonding eliminates the danger of sparks arcing between unconnected metal members, eliminates electrical disturbances resulting from rubbing and vibration contacts of metal parts, and lowers the resistance of shielding so as to ground electrical disturbances effectively. In this way, bonding reduces fire hazard and prevents interference with radio operation. All isolated metal members over 3 inches in length, such as tubing, must have at least one bond to the major framework of the aircraft. A plain metal clamp can be used for this bonding purpose, and is connected with a flexible bonding jumper. (See fig. 5–18.)

QUIZ

1. The type of oxygen system used on transport planes at noncrew stations is
    a. automatic positive pressure
    b. diluter demand
    c. composite diluter demand
    d. automatic continuous flow
2. The valve used to charge oxygen cylinders in the aircraft is the
    a. filler valve
    b. line valve
    c. topping-off valve
    d. cylinder valve
3. The high-pressure bail-out cylinder has a volume of
    a. 22.3 cubic inches
    b. 22.4 cubic inches
    c. 22 cubic inches
    d. 22.6 cubic inches
4. The high-pressure oxygen bail-out cylinder is known as the
    a. H–2
    b. A–4
    c. D–2
    d. A–6

5. The purpose of the bail-out unit is to
   - a. increase the service ceiling of installed systems
   - b. provide oxygen before bailing out
   - c. provide oxygen for a high altitude emergency bail out
   - d. provide a ready supply of oxygen in case the pilot has to bail out at 10,000 feet
6. The part of the bail-out unit that regulates the flow of oxygen from the cylinder is the
   - a. check valve
   - b. metering orifice retainer
   - c. metering orifice
   - d. breakoff nipple
7. To prevent chafing and vibration, oxygen lines are provided with
   - a. cushion clips
   - b. safety wire
   - c. tape
   - d. bonding
8. The maximum length of unsupported 3/16-inch O. D. oxygen tubing shall be
   - a. 18 inches
   - b. 24 inches
   - c. 26 inches
   - d. 36 inches
9. The maximum length of unsupported 1/8- or 5/16-inch O. D. aluminum oxygen tubing shall be
   - a. 24 inches
   - b. 18 inches
   - c. 36 inches
   - d. 26 inches
10. When two or more oxygen cylinders comprise the oxygen system, they are
    - a. mounted parallel
    - b. manifolded
    - c. mounted in series
    - d. mounted horizontally
11. All continuous flow regulators mounted in a transport aircraft are mounted
    - a. in parallel
    - b. vertically
    - c. in series
    - d. horizontally

12. To fracture the breakoff nipple on the bail-out unit the force required is
    a. 10 pounds
    b. 20 pounds
    c. 22 pounds
    d. 24 pounds
13. The useful lifetime of the bail-out assembly is considered to be
    a. 10 minutes
    b. 15 minutes
    c. 12 minutes
    d. 5 minutes
14. The maximum amount of torque that can be applied to a copper fitting on an oxygen line is
    a. 50 inch-pounds
    b. 25 to 35 inch-pounds
    c. 40 inch-pounds
    d. 25 to 30 inch-pounds
15. Aircraft with a service ceiling above 35,000 feet are being equipped with
    a. composite diluter-demand regulators
    b. continuous flow regulators
    c. AN6004 regulators
    d. automatic positive diluter-demand regulators
16. When checking for a small leak in an oxygen system, the proper solution to use is
    a. soap and water
    b. castile soap and water
    c. oxygen soap and water
    d. soft soap and water

CHAPTER 6

OXYGEN MASKS

INTRODUCTION

In the preceding chapters you learned something about the part that oxygen masks perform in a system. Their obvious purpose is to furnish a means of conveying oxygen gas to the nose and mouth of a wearer. A mask, therefore, is the last mechanical link between the individual using it and the system supplying the oxygen.

In the light of present developments, however, the oxygen breathing mask is only a step or so above the pipe-stub technique which was first used to convey oxygen to users. An open pipe stub held in the mouth was a crude method of conveyance, but it proved to be the beginning of what is now developing into the space-suit stage.

The A–8B mask, used exclusively with automatic continuous flow systems, adequately serves its purpose in a limited field, that field being the servicing of passengers or troops who are not required to exert themselves in performing duties about the aircraft. Individuals using the A–8B may be transported to relatively high altitudes in spite of the fact that this design is wasteful of oxygen, as compared to other types in the same range.

The A–14 or demand type mask is more practical and useful than the A–8B mask. It is not as wasteful of oxygen, and because of its shape, forms a better seal around the contours of the face. The A–14 also introduced a simple type of exhalation valve which prevented the air outside the mask from diluting the oxygen inside the mask when the user inhaled. The addition of a corrugated, greater diameter, mask tube in the A–14 mask made it possible to deliver oxygen in greater quantities under less pressure. This is a distinct advantage over the smooth, small diameter tube of the A–8B. These developments, of course, go hand in hand with the advantages of the demand type system over the continuous flow type. The sum total of the advantages of a demand system is evidenced by the fact that aircrewmen are able to fly higher and exert themselves more without fatigue. These advantages are important, but like most everything else are limited because of the increasingly less ambient pressure found at greater altitudes and the consequent internal leakage, despite a tight-fitting mask.

The diluter-demand system delivers oxygen into the lungs at the same pressure as that of the surrounding air (ambient pressure). An ordinary demand system is satisfactory for routine use up to a minimum of 37,500 feet and for emergency use up to 40,000 feet over very short periods of time. A PRESSURE-DEMAND SYSTEM is satisfactory for routine use up to a maximum of 43,000 feet and for emergency use up to 45,000 feet over short periods. All this ties into one major consideration, the mask and its adaptability to the system and the user. No system is any better than the final instrument it uses in getting oxygen into an individual's lungs. At present the best means at our disposal for getting oxygen into an airman is through a mask. Experience with the regions above a 35,000-foot altitude has taught us about the extreme lack of pressure there; and pressure, as we know, is so necessary to drive the life-supporting element, oxygen, into our blood stream. The problem of delivering oxygen in the proper quantities and under the correct pressure is a difficult one. This problem is somewhat solved by pressure breathing. Pressure breathing raises the pressure of the oxygen delivered to the lungs slightly above that of the air outside the body. It is not much, and never more than the amount of added air pressure one would encounter if he dropped from 1,000 feet to sea level. The body cannot take a great deal of this unequal pressure, delivered only at the nose and mouth areas. Too much of this unequal pressure tends to tire airmen and also causes the blood to circulate slowly and stagnate.

An interesting factor about pressure breathing is that you breathe differently than normal from the mechanical standpoint. In normal breathing, you exert a slight amount of muscular effort to expand the chest and suck air into your lungs. As soon as you relax your chest muscles, you push the air out without effort. In pressure breathing, sufficient pressure is added to that of the atmosphere to inflate the lungs automatically. You get a lung full without trying and it takes a small amount of effort to breathe out. One is conscious of breathing out, but not in.

The PRESSURE-DEMAND oxygen system, capable of diluting oxygen automatically at the prescribed altitudes, is the same as the ordinary diluter-demand system except for the regulator and the mask. All the latest pressure regulators are equipped with a manual means of actuating a preset amount of "safety pressure," while some regulators are fitted with an automatic means (a large aneroid) of regulating the additional amount of pressure needed. The automatic types continue to increase the pressure as the aircraft climbs higher. Aircraft equipped with regulators not having an automatic pressure feature require manual control before the necessary safety pressure can be delivered. To prevent inboard mask leakage above 35,000 feet, the safety pressure setting must be actuated on manual type regulators. At lower altitudes, when hypoxia is suspected, the SAFETY PRESS may be actuated. In fact, the safety press can be used on manual or automatic pressure type regulators at any time. However, this practice uses the oxygen supply rapidly.

With safety pressure, outside air can no longer leak into a mask because oxygen is pushing outward, even when you take a breath. The pressure-demand mask is designed to seal itself to the face against inside pressure. The inside pressure works against the inner lip contour of the mask, creating a tighter seal during the entire breathing cycle. Thus, it differs from the regular demand mask, where the seal is against outside pressure. The compensated type of exhalation valve, in the floor of the pressure-demand mask, opens only when under pressure slightly in excess of the pressure of oxygen coming in from the mask tube. When exhaling, the pressure is overpowered and the exhaust valve opens while check valves close the oxygen inlets. Sometimes it takes a considerable amount of force to overpower the pressure created on the underside of the exhaust valve. This cannot be helped as it is inherent in the design, a design which is the best under the limited circumstances of delivering oxygen through the confined medium of a mask.

PRESSURE BREATHING MASK

The pressure breathing mask (A–13A or MS–22001) consists of a facepiece, inhalation valves, pressure compensating exhalation valve, microphone port, harness assembly, and breathing tube assembly. (See figs. 6–1 and 6–2.) Oxygen enters the facepiece through ports located on either side of the mask, while exhaled air passes out through a port in the bottom of the mask, the ports being fitted with appropriate valves.

The mask, with the exception of the metal yoke assembly, suspension straps, and laminated face seal, is molded from a

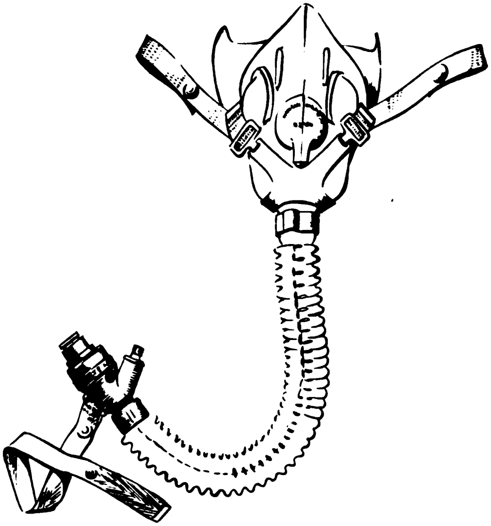


Figure 6–1.—Pressure mask.

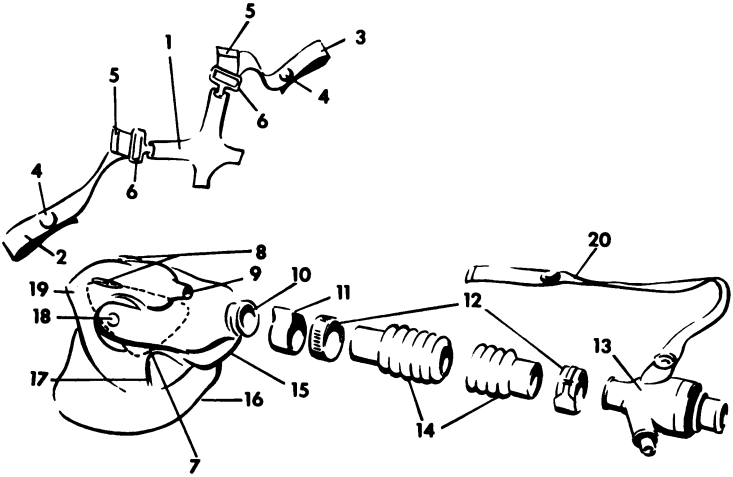


Figure 6–2.—Oxygen mask MS–22001, exploded view.

1. Metal yoke assembly.
2. Right suspension strap.
3. Left suspension strap.
4. Three-way locking snap.
5. Ferrule.
6. Buckle.
7. Laminated face seal.
8. Upper lugs (removed).
9. Microphone plug.
10. Breathing tube insert.
11. Microphone cable guide.
12. Hose clamps.
13. Connector assembly.
14. Corrugated tube.
15. Exhalation port.
16. Facepiece.
17. Lower lug.
18. Lead-in duct.
19. Facepiece.
20. Security strap.

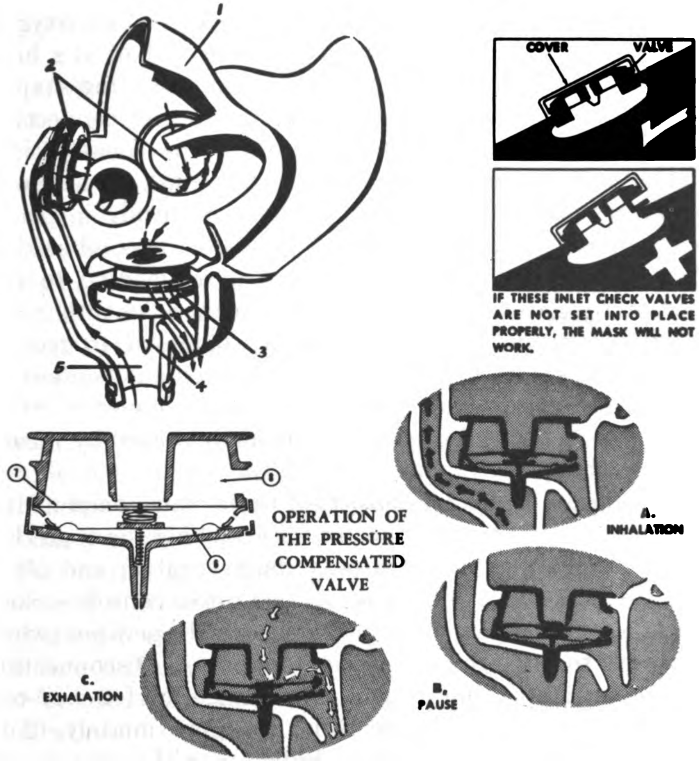
high crude rubber content stock of a medium green color. This stock is compounded to resist mildew and remain flexible at a low temperature. Two rubber suspension lugs, incorporated on the front of the mask, supported a plastic nosepiece and a suspension harness until recently modified as shown in figure 6–2. A plastic nosepiece mounted on the lugs was held in position by the suspension harness which is composed of webbed straps equipped with hardware. Each side of the webbed straps is fitted with a three-way locking snap. Connected to the bottom of the mask and held in place by a clamp is a pliable rubber corrugated delivery tube. The lower end of this tube is provided with a combination bail-out connector.

The facepiece of the oxygen mask is the medium through which the gaseous oxygen is transmitted to the individual. Therefore, the internal lip contour of the mask is shaped to provide a tight leakproof fit (1, fig. 6–3). A nose strap is used to aid in maintaining a leakproof seal. The cheek flaps provide the means of protection against frostbite and flash fire burns.

The inhalation valve assembly (2, fig. 6–3) is composed of a plastic valve seat, a rubber flapper, a valve gasket, and a plastic cover. The oxygen passes through an integral inlet tube located inside the mask at a point where it fits on the chin. The oxygen is then fed to the interior of the mask by way of two inlet ducts, one on each side of the mask. These two inlet ducts terminate as inhalation ports through which the oxygen is made available to the wearer of the mask. The inhalation check valves (round rubber covers) prevent the exhaled air from passing back through the inhalation ducts of the facepiece. A plastic cover eliminates the collection of moisture around the valve where it may freeze under extremely cold conditions.

The pressure-compensating exhalation valve, (3) in figure 6–3, is made to fit into the exhalation valve port. This valve consists of a housing with a tube (4) which extends through a hole in the wall that separates the exhalation port housing and the inhalation ducts. This arrangement permits the open end of the tube to be exposed to the oxygen as it passes from the inhalation duct into the facepiece (5). The tube of the exhalation valve brings oxygen pressure to bear against the lower side of the compensating diaphragm (6) of the valve. This pressure, plus the pressure of a calibrated spring, causes the diaphragm to close the valve; no oxygen can escape in the facepiece in this position. As the pressure in the facepiece is increased against the main diaphragm (7), because of exhalation of the wearer, the combined pressure in the inhalation duct and of the calibrated spring is overcome, and the valve opens. Exhaled air (8) escapes from the exhalation port at the bottom of the facepiece. The valve is so constructed that a pressure of only 1 mm. of mercury greater than that of which is being supplied by the regulator will force it to open.

The harness assembly serves to hold the mask close to the face. It is attached to the facepiece at the bottom by a metal yoke having one right and one left suspension strap. Two three-way snaps, located on each side of the harness secure the suspension straps to the helmet.



IF THESE INLET CHECK VALVES ARE NOT SET INTO PLACE PROPERLY, THE MASK WILL NOT WORK.

OPERATION OF THE PRESSURE COMPENSATED VALVE

Figure 6–3.—Operation of the pressure type mask.

A. ***Inhalation.***—The inlet pressure is greater than the pressure inside the mask during inhalation. The compensating diaphragm (6) is pushed up against the main diaphragm (7), closing the exhalation valve.

B. ***Pause between inhalation and exhalation.***—The inlet pressure and the pressure inside the mask are momentarily equal. The valve remains closed.

C. ***Exhalation.***—The pressure inside the mask momentarily increases slightly above the inlet pressure, so that the main diaphragm and the compensating diaphragm are pushed down, permitting the exhaled breath to pass through the valve and the outlet.

The microphone port is located in the front of the mask near the center. It is a molded integral part of the facepiece. The microphone port is designed to accommodate the standard mask microphone. At the base of the port is a lead-in channel for the electrical wire connection. When the microphone is not used, the channel must be plugged with a rubber stopper.

The corrugated hose is the medium through which oxygen is carried into the inhalation duct. The end of the hose that is attached to the mask has a smooth ring-shaped protrusion which fits over an indented mating connection on the bottom of the facepiece. This type construction, together with a plastic insert in the intake duct of the mask and a hose clamp, serves to hold the joint firmly in place. On the opposite end of the hose is inserted the combination bail-out connector. This end of the hose, leading to the pressure regulator, is also equipped with a smooth ring-shaped protrusion which is internally indented to receive and make a secure connection with the bail-out connector. The connecting extension of the bail-out connector, after insertion into the end of the hose, is made secure by means of a hose clamp.

The bail-out connector consists of three main components: (1) a side bayonet type connector for attaching the type H–2 bail-out assembly; (2) a two-way flapper valve; and (3) a quick disconnect type fitting to connect into a console socket. The two-way flapper valve permits normal operation when connected to the aircraft's oxygen supply. Disconnecting from the aircraft's supply and activating the H–2 bail-out assembly will cause pressure equal to approximately 12 to 14 inches of water pressure to build up within the mask. This, in effect, creates pressure breathing in the mask with which the user can make a free-fall parachute escape from a maximum altitude of 50,000 feet.

Microphone Installation

To install the ANB–M–C1 microphone, follow the procedure outlined below:

1. Disassemble mask and clean facepiece and corrugated

hose in a solution of mild soap, Specification NavAer C–120, and warm water. Remove all traces of any white granular substance which may be present in new masks. If not removed, an excessive amount of these tiny granules can become trapped under the rubber flaps of the inhalation valves thereby preventing a perfect seat. The inhalation valves and their rubber valve flaps must be perfectly seated to prevent an equalizing back pressure into the mask tube. Such a condition will prevent use of the exhalation valve.

2. Before installing the exhalation valve, clean it in a solution of methyl alcohol, removing dirt and dust particles that lie between the diaphragms and their contacting seats. Particles of dirt trapped under the diaphragm can prevent the exhalation valve from closing off, thereby permitting outside air to be drawn in, diluting the oxygen. Dry and reassemble mask with the exception of the inhalation valves. Leaving the inhalation valves out of the facepiece until after the microphone is installed, makes it easier to install. To prevent moisture from later forming in the microphone cavity and damaging the installed microphone, it must be vented. This vent, no greater in diameter than 0.030 of an inch, is burned through the center of the microphone cavity with a hot wire. After this operation has been performed, the mask cannot be used unless a microphone is installed in the cavity, thus sealing off leakage from the vent. In the event a microphone cannot be reinstalled in the empty vented-mask cavity, the vent can be plugged. However, it is indeed unlikely, excepting emergencies, that a mask will ever be used without being provided with a means of communication.

3. Remove the microphone cord hole plug by pulling it out at the front of the mask. (See (A), fig. 6–4.)

4. Pass the microphone cable through the rubber guide at the front of the mask. (See (B), fig. 6–4.)

5. Insert tapered long nose pliers through mike cord hole from inside the mask; tips of pliers must show at least ⅛ of an inch beyond outside edge of hole. (See (C), fig. 6–4.)

6. With the pliers opened slightly, just enough to permit a sure grip on the outer diameter of the cord, insert the

end of microphone cable through elongated hole. Handle pliers carefully in order to avoid tearing the hole and the rubber bridge piece joining the inner mask lips. (See (D), fig. 6–4.)

7. Pull enough cable up into the mask so as to gain an adequate length for connecting the terminals to the microphone. Once the outer diameter of the microphone cable has been grasped by the pliers, do not loosen the grip until the cable has been drawn through the hole. Loosening the grip while drawing the cable through the hole usually results in a second unseen grip on the frail terminal wires with subsequent damage to the cables and/or terminal ends. (See (E), fig. 6–4.)

8. Remove the microphone from its plastic adapter by unscrewing. Remove the three connections from the back side of the microphone. (See (F), fig. 6–4.)

9. Attach the wire terminals to the microphone with the lockwashers beneath the terminals. (See (A), fig. 6–5.)

10. After the terminals have been connected, draw the mike down to its cavity in the forward portion of the mask. Do not pull the cord abruptly, and stop the pulling action when the mike is flush with the rim of the cavity. (See (B), fig. 6–5.)

11. Using your thumbs on the inside of the mask and in contact with the mike, work the mike into its cavity slowly and progressively. When a part of the mike has been entered into its seat, try pulling out more of the surplus cable. When doing this, be careful not to break the terminal connections. Completely seat the mike in its cavity. (See (C), fig. 6–5.)

12. Being exceptionally careful, pull out all the remaining surplus cable and remove the slack between the guide and where it emerges from the hole. (See (D), fig. 6–5.)

13. Replace the inhalation valves and covers, arrows down. If the inside surface of the plastic covers have not been scored to prevent the rubber valves from sticking to them, see the latest applicable publication referencing the modification. It is reasonable to believe that all subsequent inhalation valve covers to be manufactured will be modified,

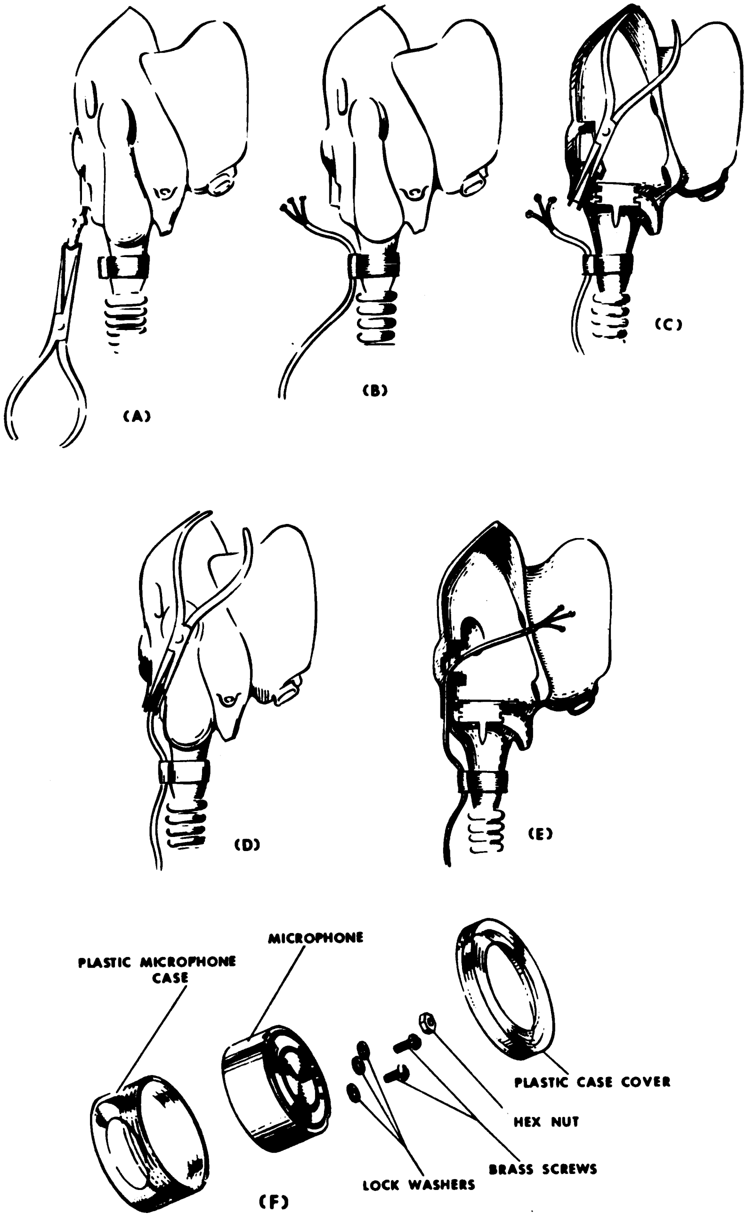


Figure 6–4.—Installation steps of the ANB–M–C1 microphone.

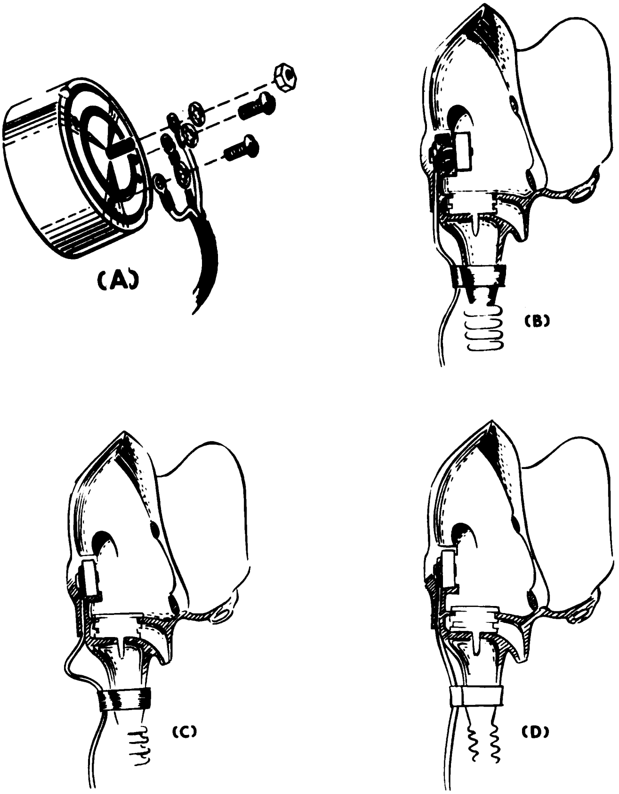


Figure 6–5.—Installation steps of the ANB–M–C1 microphone.

making the field change unnecessary. Figure 6–3 illustrates the proper seating of an inhalation valve in its port.

14. Place the mask to your face, and test its breathing action on a mockup system, using safety pressure. Also test the bayonette bail-out coupling using a locally made connection and system.

15. Have the mike bench checked, making certain that it will work properly.

Fitting the Mask

The pressure mask (A–13A and MS–22001) is supplied in three sizes—small, medium, and large. The correct size will hug the face comfortably, and the inside flap will fit tightly all around the nose and mouth area. The oxygen mask is classified as pilot's and aircrewmen's PERSONAL gear. What item of equipment could be more personal, since the mask is the airman's link between life and death at high altitudes? Masks are issued through regular supply channels under the supervision of the Supply Officer, through the Flight Clothing Issue Section of the Supply Department. After drawing new flight gear, a pilot will take this equipment to the parachute loft for assembly and fitting, especially when items like the hard-shelled helmet, liner, microphone, and mask are included in his list. The headphones used in the helmet liner are installed by electronics personnel.

When a pilot or airman has selected the size mask best suited to his face, the Parachute Rigger will have no difficulty in aiding him to adjust the mask properly, thereby obtaining a secure and comfortable fit. Occasionally, however, no detail of the fitting process is successful. The individual concerned in the problem may have sharp features or the bridge of his nose and the indentation between chin and lips may be so confined that none of the three mask sizes available can be adjusted to a leakproof fit. What can be done in a case like this? Fortunately, the problem of successfully fitting the nonconforming features of an individual is not entirely hopeless. Portions of the inner lip of the mask can be built up (to make a better seal), using a thin layer of specially developed soft sponge rubber laminate cemented in areas where the leakage is occurring. Ordinary sponge rubber cannot be used.

For application of the laminate (sponge-like material), the following instructions will apply:

1. Roughen the sealing surface of the inner lip of the mask with emery paper.
2. Apply an even, medium weight coat of cement to the rough side of the laminate and to the surface of the mask just roughened.
3. Line up and determine the top and bottom centerlines of the inner lip and the laminate in preparation for sticking the pieces together.

4. When the cement is tacky, gently lay the upper nose section of the laminate in place, lining up with the centerlines concerned. While doing this, take care not to make contact with the lower portion until the proper overall alignment has been assured.

5. After aligning the laminate with the inner lip surface of the mask, lay it in place pressing tightly together. Allow the contacting surfaces to dry thoroughly—for about an hour. If the laminate is wrinkled or not positioned correctly, strip it from the facepiece, cleaning the surface with solvent before installing a new seal.

6. Masks fitted with this additional laminated seal require added care in handling, especially when they are periodically cleaned with a soft soap solution to remove particles of dirt and dried perspiration.

To install a new metal yoke harness assembly, the mask tube must be removed and the yoke slipped on over the breathing-tube extension of the mask. After this, the tube is secured back in place. The metal yoke and harness combination was designed to replace the old style harness which was suspended higher on the mask through the use of molded rubber lugs. By suspending the mask from a lower position and adding a laminated surface to the inner lip of the facepiece, a better and more comfortable fit for a greater number of individuals was made possible.

All type A13–A oxygen masks currently in use are satisfactory for flights up to 43,000 feet altitude without regard to service life, if properly serviced. New production masks will be fitted with the laminar seals and metal yoke assemblies. Masks which have been modified in the field will eventually be replaced by the production models (either the entire mask assembly or just the facepiece in accordance with conditions) as soon as they are made available.

In other words, the field modification was only an interim measure designed to serve the greatest number in the shortest period of time with the improvement. Consequently, masks in use prior to 1 January 1956 (old masks modified in the field) are regarded as expended from stock.

The replaced masks will not be turned into supply, but will be retained by squadron or station as spares, and will be modified when yokes and seals become available. All necessary repairing and component replacement of old or new mask assemblies and components will be performed by the organization using the equipment or other authorized activities in accordance with instructions. Masks found to be irreparable may be exchanged for new ones at the nearest source of supply, but not until they have been disfigured and suitably tagged or marked to prevent reissue. The old disfigured masks are then destroyed unless otherwise directed.

The normal adjustment steps involved in fitting a pressure type mask follows:

1. Place the mask over the nose and mouth. While holding the mask in position, check its fit by stopping off the bail-out connector's inlet. Try inhaling GENTLY to see if the mask will cling to the contours of the face, making further inhalation impossible. This is merely a preliminary check to see that the size selected (small, medium, or large) is suitable. If the size selected is not suitable, inhalation will most likely be made possible by a poor seal around the bridge of the nose. When the preliminary fitting proves successful, go on to the next step.

2. Place the under-helmet liner on the head, adjusting and tightening the chin strap. Attach the mask harness to the liner as shown in figure 6–6 and adjust to a comfortable but secure fit. Mask cheek flaps should be under the liner against the face. Cheek flaps may be trimmed if the mask proves to be uncomfortable under the liner. In some cases it might be advisable to completely trim off the cheek flaps up to the inner lip portion. Make a second preliminary check for mask leakage as described in step 1.

3. Apply metal tips to the ends of the harness webbing straps after they have been trimmed to about a 2-inch length.

4. With both inhalation valves and the compensated exhalation valve installed in the mask assembly, place a clean smooth rubber stopper (size #1 or its equal) firmly in the oxygen inlet end of the end connector assembly attached to the end of the mask hose and perform the following tests:

a. To test the inhalation valves, hold the mask close to the face, but not sealed to the face. While supporting the connector at the end of the mask hose steadily in the hand, inhale deeply. After inhaling, press the mask to the face and exhale forcibly and completely through the exhalation valve. If the inhalation valves are not closing properly, the exhalation valve will not open. If the inhalation valves are seated properly, the exhalation action will be smooth with a minimum of resistance noted.

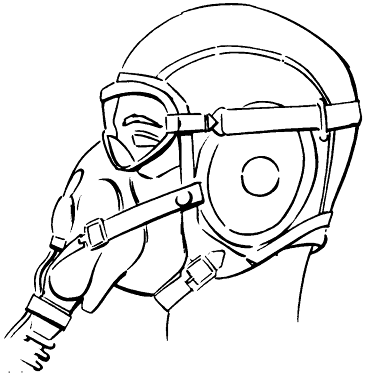


Figure 6–6.—Mask adjusted to helmet liner.

b. To test the exhalation valve, place an obstruction (rubber band or equivalent) under the rubber flapper of one of the inhalation valves in a manner to prevent the flapper from forming a seal. Repeat the testing procedure described in step 1. If the exhalation valve is functioning properly, it will NOT open when the subject exhales, and exhalation through the valve will not be possible.

c. To test for mask hose and fitting leakage, remove the stopper, affix the mask assembly to the face with the helmet in place and, using the mask suspension harness, adjust the straps for a snug comfortable leaktight fit. Again, block off the inlet port of the mask hose connector assembly, inhale sharply and deeply, holding or attempting the inhalation action as long as possible. If there is no inboard leakage, immediate signs of suffocation will be evident.

5. As a preflight inspection (mask leakage test in the aircraft), check the mask in the following manner:

Adjust the mask securely in place and connect it to the regulator breathing extension tube or console. With the oxygen system turned on, place the regulator safety pressure selector lever in the ON position. Induce a severe outboard mask leakage by placing two fingers under the mask sealing surface and observe the flow indicator which should remain in the flow position. Repositioning the mask on the face, and after a few respirations, hold the breath and again observe the flow indicator. If there is no mask leakage, the flow indicator will remain in the NO FLOW position. Leakage will cause the flow indicator to assume an actuated position. Adjust the suspension straps until the leakage is stopped, if possible. Return the safety pressure selector lever to the OFF position.

DO NOT USE A MASK THAT LEAKS! This is the final ground-leak test that can be given a mask where a decompression chamber and medical examiners are not available. A mock-up oxygen system, installed in the shop or loft, can be used to make the final ground-leak test. If this cannot be done, due to a critical supply condition, the test must be carried out on an aircraft system.

To check mask fit during flight, actuate the safety pressure. Take a deep breath and hold it. Note position of the oxygen flow indicator. If flow indicator opens, excessive leakage is indicated. Tighten mask straps until flow indicator closes. Because of characteristics of the flow indicator, this test cannot be conducted at pressure-breathing altitudes; however, the outward flow of oxygen into the eyes (providing goggles are removed or do not fit tightly) from a leaking mask is readily detectable.

Service Inspection

Preflight tests should be made to establish the security of all parts, with special attention given to the inlet check valves and exhalation valve. The plastic shields must be scored on the inside and be snap seated over the inlet valves.

The arrows on the shields should point downward to prevent excessive moisture in the valves. The inlet valves and exhalation valve must be free from dirt and dust particles. A preflight test should be made just prior to each flight by attaching the mask to the pressure-demand regulator installed in the aircraft. The operational check should be under both demand and pressure-demand conditions. In the event any difficulty is encountered, the flight should be canceled or the oxygen mask replaced.

Maintenance

Since the oxygen mask is worn next to the skin, it should be kept as clean as possible. This will not only help to make the mask more comfortable, but it will also reduce the danger of infection and will prolong the life of the mask. For ordinary cleaning, which should be done after each flight, the mask should be washed with a pure soap solution (C–120). If a microphone is installed, which is most likely, a clean swab should be used instead of running water, in order to keep the microphone from getting wet. To disinfect an oxygen mask, swab it carefully and thoroughly with a gauze pad which has been soaked in a water solution of clear merthiolate (1 gram merthiolate to 1,000 cc. water). Wipe the mask with a clean cloth and let it dry before it is used. Surgical sponges may be used as sterile swabs.

While not in use, the mask should be kept in a clean dry place (preferably in a container) away from sunlight and heat as much as possible. Oxygen masks should be stored at temperatures in the range of 32° to 80° F.; 70° being ideal. The individual's mask should be checked for its fitting qualities periodically. As rubber ages, it becomes stiff and brittle. When cracks appear in the rubber similar in appearance to the cracks found in the side walls of old automobile tires, replace the mask. Do not attempt to repair defective valves; return unserviceable valves through regular supply channels. Figure 6–7, a cutaway view of the pressure mask, illustrates the valves properly seated.

Creams, salves, oils, and cosmetics of any kind should not be applied to the face where the mask and oxygen will

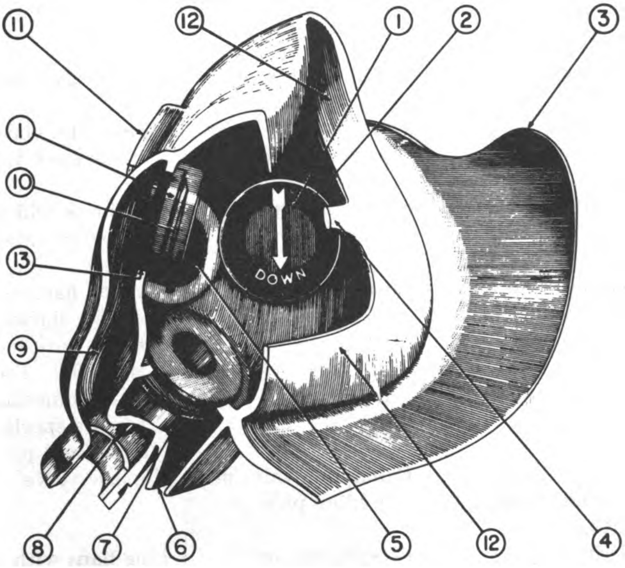


Figure 6–7.—Cutaway view of pressure mask. Note how the valves are seated.

1. Inlet valves.
2. Plastic shield.
3. Cheek flap.
4. Lip flap.
5. Microphone port.
6. Exhalation port.
7. Exhalation valve component.
8. Exhalation valve protrusion.
9. Inhalation duct.
10. Inlet valve flapper.
11. Lug.
12. Sealing lip.
13. Inlet valve gasket.

come in contact with them. The best way to avoid skin irritations and infection is to keep the mask and face clean. If perspiration is excessive, causing infection, the cheek flaps may be lined with chamois or may be trimmed off. For service troubles and remedies see table 6–1.

When disassembling and assembling the mask parts, be careful not to tear the rubber. Removal of the suspension harness and valves is self-evident. Figure 6–8 illustrates the removal of the corrugated mask tube. The bail-out connector is removed in the same manner. The inside of the mask tube can be cleaned with a pure soap and water

Table 6-1.—Service troubles and remedies.

Trouble	Probable cause	Remedy
Inlet check valve does not hold suction.	Valve not seated properly.	Insert valve correctly.
	Inlet check valve gasket not in place.	Insert inlet check valve gasket.
Moisture in inlet check valve.	Shield improperly placed.	Position shield with arrow pointing down.
Air leaking from mask during respiratory cycle.	Loose suspension in harness.	Tighten harness straps, shifting tensions to secure a tight fit. Problem cases sometimes require special slings and padding.
Oxygen continues to flow while holding breath.	Exhalation valve not holding pressure.	Replace valve.
Skin irritated----------	Perspiration on cheek and chin flaps.	Line flaps with chamois or trim flaps.
Mask does not fit properly on nose.	Goggle flange prevents comfortable fits.	Trim goggle flange.
Goggles fit uncomfortably.	Goggles placed in front of mask.	Place goggles behind mask. Do not disturb seal.
Lip strap uncomfortable.	Temporary condition.	Use for a longer period.
Mask blocks: cannot exhale.	Dirt or foreign matter between inlet check valve body and valve flapper seats.	Clean with water weekly or as required.
	Inlet check valve body and flapper damaged or warped.	Replace defective parts with complete inlet check valve assembly.
	Exhalation valve blocked.	Replace exhalation valve.

Table 6-1.—Service troubles and remedies—Continued

Trouble	Probable cause	Remedy
Inlet flapper valves stick to inside of plastic covers when bail-out cylinder is actuated.	Smooth surface offers no resistance to suction.	Score inside covers in accordance with BuAer AC/SB 50-54.

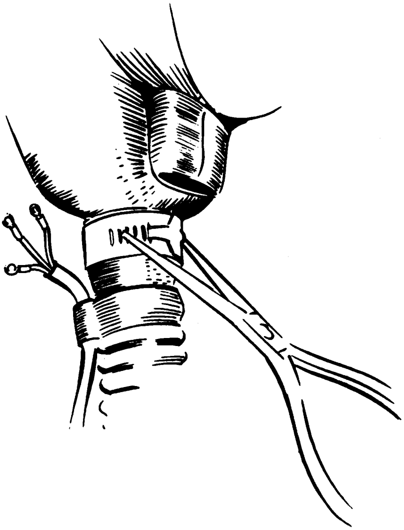


Figure 6-8.—Removing the mask tube.

solution, using an ordinary test-tube brush approximately 1½ inches in diameter. With the mask inlet insert removed the brush may be used in the mask ducts leading to the inlet valve ports.

In reassembling the mask parts, place the compensating valve in the exhalation chamber. The pressure nipple should be directed into the hole leading from the exhalation chamber to the inlet chamber. Then seat the valve in the recess formed by the inner contours of the mask. Check the valve seating to insure that there is no leakage and that the pressure nipple protrudes into the inlet chamber. (See fig. 6–7.) The inhalation check valves must be inserted into the inlet valve port recesses. Either one or two rubber bands are necessary, 1/8 inch wide, 1/32 inch thick by 7/8 inch inside diameter, inserted into the valve recess to make a leaktight seal. (See fig. 6–9.)

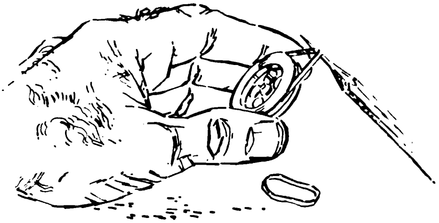


Figure 6–9.—Rubber bands inserted in inlet valve recess.

Replace mask inlet insert and harness yoke before reattaching mask tube. Replace metal clamps at top and bottom of tube when it is in position on the mask and bail-out connector is inserted. Do not attempt to draw clamps too tight. Slip the rubber microphone cable guide into position over the metal clamp at the top of the hose.

Demand Oxygen Mask—A–14

The A–14 oxygen mask should be used with a demand system not having safety pressure features. It is designed to supply adequate oxygen during bodily exercise in extreme cold at an altitude up to 37,500 feet. With added precaution adequate oxygen is supplied at 40,000 feet.

The A–14 mask assembly consists of a mask body which completely covers the nose and mouth. It is fitted with an exhalation valve of the rubber flutter type. The adjustable straps of the suspension harness are arranged differently in comparison with the pressure type mask. The corrugated mask tube is equipped at the opposite end with a single male connector fitting. Regular snap fasteners (not the 3-way snap type) are provided for attachment of the mask harness to the helmet. The microphone is installed in a cavity similarly located to that in the pressure mask. Since it was not designed to hold pressure, there are no inhalation valves installed in the open ports of the A–14 mask. Its exhalation valve, as mentioned before, is very simple in construction and is designed to prevent air from entering the mask upon inhalation. This means that the rubber flapper is located on the OUTSIDE of the valve. A rubber cover, or protector, for the inhalation ports is secured to the inside of the facepiece. It is designed to prevent moisture from entering the ports and/or to prevent the formation of ice in the same vicinity.

There are no inner lips in the A–14. The exhalation valve, seated in the bottom of the mask, permits exhaled air to flow out of the mask through two ports, one on each side of the mask exterior. You will notice that one of these ports is larger than the other. The larger one allows inspection of the outer portion of the flutter valve and seating of the valve proper.

The exterior microphone cable duct on the A–14 mask is different from the pressure type's cable duct. In order to gain entrance of the cable to the cavity, the tip of the projecting smooth molded cable duct must be cut off. In doing this, care must be taken not to cut off too much of

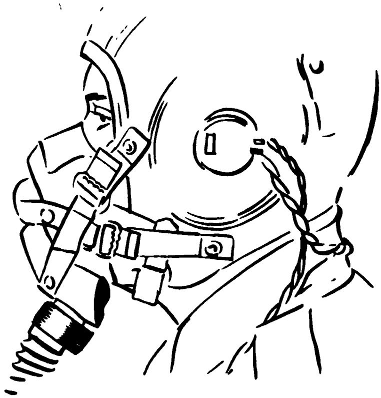


Figure 6–10.—Left view of mask showing relative securing position of the ends of straps to the helmet.

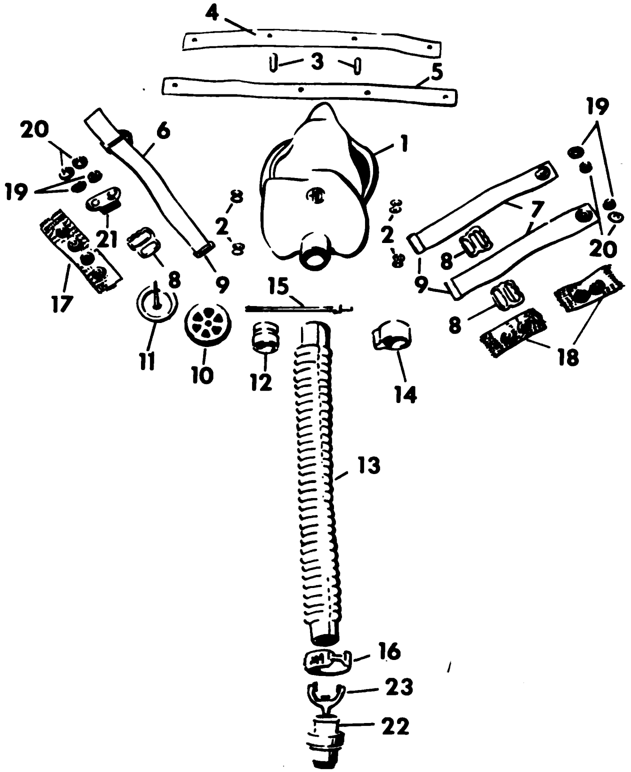


Figure 6–11.—A–14 mask—exploded view.

1. Mask body with antifreeze flap.
2. Strap retaining buttons.
3. Strap retaining loops.
4. Upper retaining strap.
5. Lower retaining strap.
6. Right adjusting strap with loop.
7. Left adjusting strap with snap.
8. Release buckle.
9. Clinch type ferrules.
10. Exhalation valve seat.
11. Exhalation flapper valve.
12. Mask inlet bushing.
13. Corrugated mask tubing.
14. Tube and wire guide.
15. Tubing clamp, strap type.
16. Tubing clamp, snap type.
17. 4-stud fastener.
18. 2-stud fastener.
19. Stud.
20. Eyelet.
21. Hook—side helmet.
22. Fitting assembly—oxygen mask to regulator connector, male.
23. Lock—demand mask disconnect, positive.

the tip. Removing an excessive amount of duct will result in a hole too large in diameter to adequately seal itself around the cable.

The A–14 mask is available in three sizes: large, medium, and small. The mask is worn as shown in figure 6–10. Figure 6–11 shows an exploded view of the mask.

Fitting the Mask

The pressure type mask is usable with any demand type regulator and may be substituted whenever type A–14 masks are used; however, the substitution of A–14 masks for pressure types is not permissible.

The normal fitting procedure follows:

1. Select the size mask (small, medium, or large) which corresponds to the facial characteristics of the individual to be fitted.

2. To effect a proper and comfortable integration of oxygen mask and helmet, the assistance of a Parachute Rigger is needed.

   a. Have the individual put on his helmet.

   b. Have wearer hold the mask so that it fits snugly to the face (fig. 6–12).

   c. Hold adjustable straps on left side of mask up to the helmet so that the snap fasteners are in the most suitable position. Mark clearly the location for the helmet studs by inserting a pencil point through the center hole of the sockets. (See fig. 6–13.)

   d. To position the helmet studs on the right side, engage the buckle loop of the mask suspension strap with the helmet sidehook and follow the above procedure for determining and marking the positions of the right-side helmet studs. (See fig. 6–14.)

3. When the helmet stud positions have been marked, remove the helmet and mask and attach studs as follows: For SUMMER HELMETS, three helmet webbing straps, with studs attached, are provided. Those straps with two studs each are sewed to the left side of the helmet in accordance with the markings. The four-stud piece of webbing is sewed

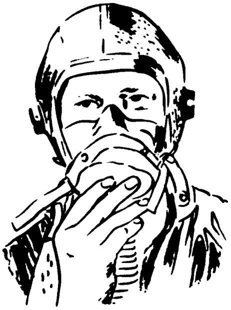


Figure 6–12.—Wearer holding mask securely to face.

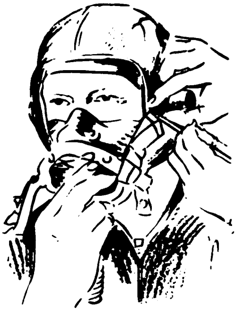


Figure 6–13.—Marking position for top strap.

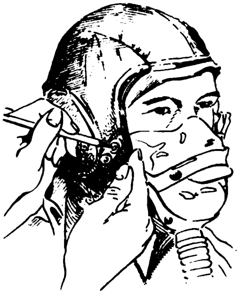


Figure 6–14.—Marking position for right-side attachments.

on the right side. The webbing straps are necessary for reinforcement of the studs. The four-stud arrangement makes it possible to shift the position (higher or lower) of the right-side adjustment strap containing the loop.

4. The studs may be individually positioned on summer type helmets as well as winter type helmets, but reinforcement is necessary to prevent tearing of the lightweight helmet. Therefore, apply the stud so that a reinforcing tape will completely enfold the base of the stud with the face end of the material fastened beneath it. (See fig. 6–15.) The tape besides acting as a reinforcement also prevents contact of the face with the metal stud base. Thus the possibility of frostbite during flights below zero is eliminated.

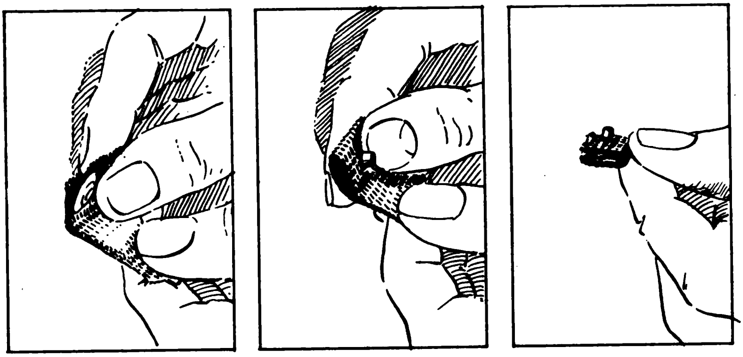


Figure 6–15.—Enfolding eyelet in tape.

5. For winter type helmets, or for any helmets to which the webbing straps cannot be conveniently sewed, individual studs and eyelets should be attached. Using a revolving eyelet punch, make the number of holes necessary at the located points through the helmet, and set the fasteners. To prevent metal contact with the face, a piece of tape can be sewed over the bases of the eyelets. If this is impractical, a piece of fabric cut to size may be cemented directly over each eyelet base.

6. Snap helmet sidehook securely to the right-side helmet studs and retain it on the helmet.

7. Put on the helmet and attach the mask. Tighten suspension straps until mask is snug and comfortable, equal tension all around. Cut off excess length, if any, of suspension straps and secure loose ends with metal clinches.

8. Test mask for leakage by placing thumb over disconnect at end of mask tube and inhale GENTLY. If there is no apparent leakage, the mask will adhere to the face and further inhalation will be impossible. A LEAK TESTER is a more accurate means of testing for mask leakage and should be used during the first mask fitting and at frequent intervals thereafter to test the mask for leakage. The tester consists of a sealed bellows housed inside a circular case. Take several normal breaths. Then HOLD BREATH as the leak tester is attached to the disconnect. Continue to hold breath for ten more seconds. If at the end of this time the

bellows of the leak tester has not become fully expanded (fig. 6–16), the mask fit is satisfactory. If the bellows expands fully in ten seconds or less (fig. 6–17), the mask fit must be improved and retested.

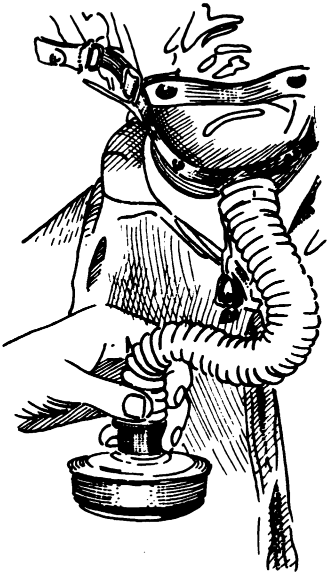


Figure 6–16.—Bellows not expanded—negligible leakage.

9. To remedy leaks, adjust suspension straps and/or NOSE WIRE for type A–14 masks. In making a nose wire adjustment, remove the mask. Place one thumb against the wire near the edge of the mask and place the other where the wire turns to form an arc. As a checking device, place the index finger on the inside of the nose bridge against the center of the wire. Bend the wire inward, making the bridge of the nosepiece smaller. Retest the mask fit.

The A–14 mask can be suspended by the use of a head harness instead of being secured to a helmet. A head strap assembly may be worn by transport and patrol pilots whose missions do not normally require flights above 25,000 feet and

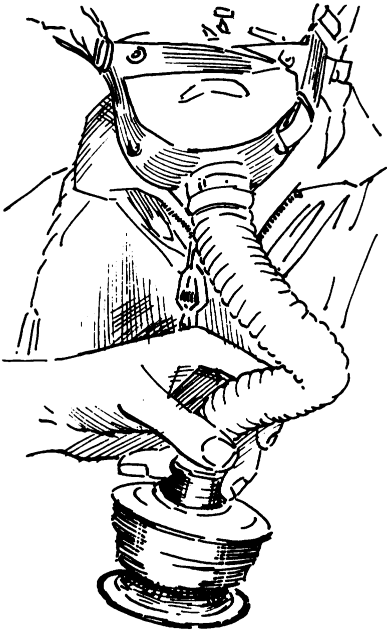


Figure 6–17.—Bellows completely expanded—excessive leakage.

who do not require head and facial protection. To connect the mask for use with the head strap proceed as follows:

1. The rubber retaining straps on the left side of the mask should be reassembled to duplicate the mask rubber strap arrangement on the right side.
2. The head strap ends are passed through the mask buckles as shown in figure 6–18.

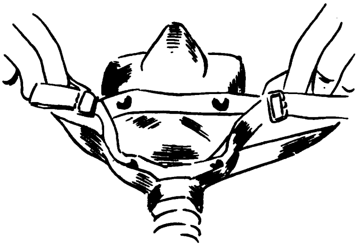


Figure 6–18.—Reassemble mask retaining straps.

3. Pass the head harness side straps through the buckles. Put on the head harness and adjust the side straps to hold the mask snugly to the face, making a leaktight fit. (See fig. 6–19.)

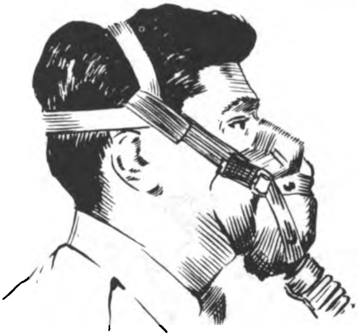


Figure 6–19.—Head strap and mask arrangement.

Maintenance

As in the case with pressure type masks having microphones installed, or any other item of equipment fitted with electrical gear, do not clean by submerging in water. For thorough cleaning, always remove the microphone and disassemble the mask and tube connections completely.

When necessary, the A–14 mask can easily be equipped with the bail-out connector used on pressure type masks. The same general line of maintenance procedure applies to this type mask as it does with the other (MS–22001 or A–13A). Being simpler in construction and lacking the valves and internal sealing arrangement incorporated in pressure types, the A–14 mask is easier to maintain in a serviceable condition. However, the same major rules apply to both masks. They must be clean and leakproof. Through repeated bendings, the nose wire (A–14) might become broken. When it does, replace the mask. The seating of the exhalation valve should be checked before each flight. An improperly seated exhalation valve will admit air upon inhalation. A system can be in perfect working order, the mask can be adjusted to a leakproof fit, but let the exhalation valve fail to stop the admittance of outside air into the mask and the entire system, working doubletime, could not stop the effects of hypoxia.

CONTINUOUS FLOW MASK—A-8B

In naval aviation the A-8B oxygen mask is used only with the A-11 (automatic continuous flow regulator), and installed in a limited number of transport and utility type

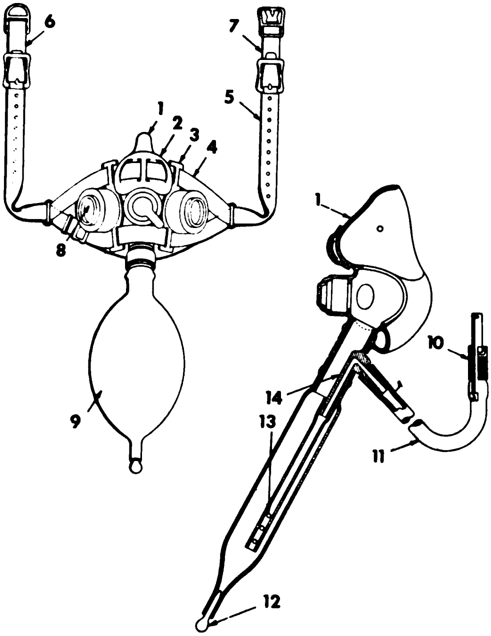


Figure 6-20.—Diagrammatic views of the A-8B mask.

1. Mask.
2. Bridge.
3. Strap holders.
4. Long band.
5. Short straps.
6. Link assembly adapter, right.
7. Link assembly adapter, left.
8. Air valve disks.
9. Oxygen mask bag (breather bag).
10. Bayonet coupling (mask tube to regulator.)
11. Mask tubing (smooth type).
12. Plug.
13. Breather bag tubing (internal).
14. Connector.

aircraft. It is easily identified by a rebreather bag and two sponge rubber disks in turrets on the facepiece.

The A-8B oxygen mask is designed to conform with the face and give surface contact which is free from pressure strains. It is made of an especially compounded latex rubber which does not stiffen in the low temperatures encountered at high altitudes. Because of the basic design of the mask and the inherent characteristics of the continuous flow system, only one size of the type A-8B is used.

Figure 6-20 illustrates diagrammatic views of the A-8B mask showing numbered parts in their assembled position and leather side straps.

Principles of Operation

Sponge rubber disks in the turrets act as inhalation and exhalation valves. When in use, the oxygen enters the mask at the inlet and is delivered to the rebreathing bag, from

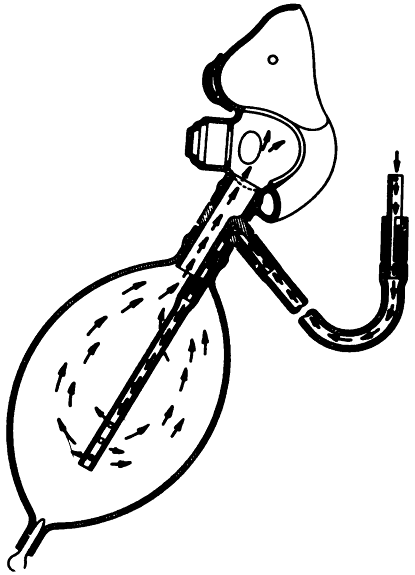


Figure 6-21.—Diagrammatic view of oxygen entering mask.

which it passes into the facepiece where it is inhaled by the wearer. The exhaled gases pass down into the bag where they meet with the incoming oxygen. As the bag becomes distended with the expended gases and the incoming oxygen, the slight pressure thus formed causes the remaining portion of the exhalation to pass out through the sponge rubber disks. The first part of the wearer's exhalation is rich in oxygen and relatively free from carbon dioxide. It passes into the rebreather bag and is available for rebreathing. The latter part of the wearer's exhalation carries the greater portion of the carbon dioxide formed in the lungs. It is this portion that escapes through the rubber disks. (See fig. 6–21.)

No more information will be given on the A–8B mask as its use is extremely limited. For those Parachute Riggers who might encounter this type, there are publications available which adequately describe its preparation for use.

QUIZ

1. An A–14 demand type mask is satisfactory for use up to
   a. 27,000 feet
   b. 35,000 feet
   c. 34,000 feet
   d. 37,500 feet
2. In an emergency the A–14 demand type mask may be used up to
   a. 10,000 feet
   b. 27,000 feet
   c. 40,000 feet
   d. 43,000 feet
3. An A–13A pressure-demand mask is satisfactory for use up to
   a. 43,000 feet
   b. 45,000 feet
   c. 37,500 feet
   d. 39,000 feet

4. In an emergency the A–13A pressure-demand mask may be used up to
   - a. 40,000 feet
   - b. 35,000 feet
   - c. 43,000 feet
   - d. 45,000 feet
5. When using a pressure-demand oxygen system at low altitudes and hypoxia is suspected, you should
   - a. actuate the safety press
   - b. actuate the emergency valve
   - c. actuate the bail-out cylinder
   - d. bail out
6. The exhalation valve of the A–13A mask is so constructed that a pressure of only ________ of mercury greater than that which is being supplied by the regulator will force it to open
   - a. 1 inch
   - b. 1 mm.
   - c. 1 p. s. i.
   - d. 2 mm.
7. When you actuate the H–2 bail-out unit, pressure will build up within the mask to approximately
   - a. 10 to 12 inches of water
   - b. 11 to 14 inches of water
   - c. 10 to 13 inches of water
   - d. 12 to 14 inches of water
8. The vent hole in the microphone cavity should be no larger than
   - a. 0.030 inch
   - b. 0.002 inch
   - c. 0.020 inch
   - d. 0.0002 inch
9. The A–13A pressure mask is manufactured in
   - a. 1 size
   - b. 5 sizes
   - c. 2 sizes
   - d. 3 sizes
10. The plastic inhalation valve covers of the A–13A oxygen mask are manufactured with a small opening in the ridge. This open section should be placed over the inhalation valves in
    - a. the side position
    - b. the up position
    - c. the down position
    - d. none of the above positions

11. The A–14 oxygen mask is checked for proper fit by placing the thumb on the
    a. female part of the quick disconnect
    b. exhalation port
    c. end of the feeder tubing
    d. end of the mask tubing and inhale

12. The maximum leakage for an oxygen mask used above 30,000 feet is
    a. 3 percent
    b. 4 percent
    c. 5 percent
    d. 6 percent

13. The A–8B has a fitting on the rubber intake tube called a
    a. screw
    b. bayonet coupling
    c. quick disconnect
    d. threaded elbow

14. Inhalation valves of an A–13A oxygen mask may be tested by
    a. covering quick-disconnect coupling and inhaling
    b. covering quick-disconnect coupling and exhaling
    c. breathing normally with mask uncoupled from feeder tube
    d. coupling up to system, actuating safety press, and inhaling deeply

15. The mask tubing on the A–14 demand type oxygen mask is
    a. wire wound, cloth covered
    b. molded of a pure resilient rubber
    c. fitted with a bayonet coupling
    d. 5/16-inch diameter smooth rubber

16. After securing a leakproof fit from the A–13A mask, the wearer must have his mask checked by the
    a. Parachute Rigger and Parachute Officer
    b. Parachute Officer and Flight Officer
    c. Safety Equipment Officer or Flight Surgeon
    d. Parachute Rigger and a Corpsman

17. To disinfect an oxygen mask, swab it carefully and thoroughly with a gauze pad which has been soaked in a water solution of
    a. clear merthiolate
    b. iodine
    c. castile soap and water
    d. pure soap

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18. When not in use, the mask should be kept in a clean dry place and away from sunlight, the ideal temperature being.
    a. 32° F. to 80° F.
    b. 32° F. to 90° F.
    c. 60° F. to 85° F.
    d. 75° F. to 130° F.
19. The A–14 oxygen mask should be used with a demand system not having
    a. projecting cable ducts
    b. safety pressure features
    c. bayonet fittings
    d. exhalation valves
20. When using the A–8B mask, the first part of exhalation is rich in oxygen and relatively free from
    a. nitrogen
    b. carbon dioxide
    c. carbon
    d. carbon monoxide
21. The A–8B oxygen mask is designed to conform with the facepiece and is made of
    a. rubber coated nylon
    b. compounded latex rubber
    c. synthetic rubber
    d. resilient rubber
22. The A–14 mask is available in
    a. 5 sizes
    b. 3 sizes
    c. 4 sizes
    d. 2 sizes

CHAPTER 7

OXYGEN TRANSFER EQUIPMENT

Oxygen may be produced, stored, and shipped in the liquid state. Before being put to work, however, the liquid must be reconverted to gas and stored under pressure in large capacity storage cylinders. The conversion equipment presently in use in the Navy is the 880-cubic foot warm converter oxygen cylinder charging equipment. This warm converter takes liquid oxygen from 150-, 450-, or 1,350-gallon storage tanks and converts it to gas, charging the gas under high pressure into cylinders. Normally, this transfer is made to standard type cylinders, 200-cubic foot capacity, at 1,800 p. s. i. pressure. Storage cylinders having a greater capacity are also being used. When the oxygen, as a gas, is to be retransferred to other cylinders, notably the smaller types used in aircraft, the process is carried out by equipment known as OXYGEN RECHARGE EQUIPMENT. The warm converter requires ONLY heat to effect its work. As the liquid oxygen evaporates, it generates the pressure needed to force it into the gas storage cylinders at high pressure. Oxygen recharge equipment, on the other hand, utilizes a "cascade" system and a power-driven pump or compressor to force oxygen gas from one gas storage cylinder into another.

Portable recharge equipment (oxygen recharge servicing trailers) effects the transfer of oxygen from large capacity storage cylinders by the simple cascading process. To accomplish this a compressor is not needed. The oxygen is forced into the lower pressure receiving cylinders by the superior pressure contained in the cylinders of the servicing trailer. When the pressure is no longer great enough to cascade the required amount, the trailer cylinders are exchanged for fully charged ones.

The use of the oxygen recharge machines, which employ compressors and transfer gaseous oxygen from storage cylinders to the smaller aircraft cylinders completely detached from their systems, is becoming limited. Most aircraft systems are being designed with oxygen filler connections, making removal of the cylinders for recharging purposes unnecessary. Those aircraft systems, which do not offer the convenience of a filler connection, and the portable walkaround cylinders, which are easily disconnected from their carrying brackets, make disconnection of the cylinders necessary for recharging and justify the maintenance of a cascading and compressor combination type machine.

Overhaul and repair shops, where cylinders must be recharged before being returned to the supply system, will continue to need such a machine. Even portable walkaround units and the cylinders that must be disconnected from their aircraft systems could be recharged by the cascading method which is used by the servicing trailer. Of course, this method causes the storage cylinders to be used at a much higher rate than would be the case where a compressor was employed. A compressor makes it possible to use more of the available oxygen in a storage cylinder by compressing and pumping it into a reservoir cylinder, the pressure of which is great enough to fill other cylinders to the required 1,800 p. s. i. This fact leads us into another consideration for justifying the maintenance of the compressor type recharge machine. Where the supply problem is acute, preventing rapid delivery of large numbers of recharged storage cylinders from outside commercial sources, the local installation of such a machine would be justifiable.

Rapidly developing is a relatively new process which will probably, except for rare occasions, make the transferring of oxygen while in a gaseous state obsolete. We are, of course, referring to the transfer of liquid oxygen from one container to another while maintaining it in a liquid state. This system of transfer will be discussed after treating the gaseous type.

OXYGEN GAS TRANSFER MACHINE

Oxygen gas recharge equipment is designed to recharge quickly and conveniently one to four high-pressure aircraft oxygen system cylinders. This is accomplished by a series of pressure equalizations known as the cascade system of recharging cylinders. In addition to facilities for conducting the pressure equalizations, the equipment is provided with a power-driven compressor which maintains a constant pressure between 2,000 and 2,200 pounds per square inch in a reservoir cylinder. This reservoir cylinder is used after the cascading operation is completed to "top off" the recharged cylinders to the required pressure. Means are provided for using this compressor unit to recharge the cylinders directly without previously using the cascade system. (See fig. 7–1.)

In the cascade method of charging, oxygen flows from the cascade cylinder into the cascade manifold, thence through two driers to the cascade master valve, and then through the receiver manifold to the receiver cylinders. When the valve to one of the compressor supply cylinders is open, oxygen flows through the supply manifold to the low-pressure cylinder of the compressor, then through the intercooler to the high-pressure cylinder of the compressor. From there it goes through the aftercooler, the mechanical water trap, and the compressor drier to the reservoir manifold. From the reservoir manifold it goes to the reservoir cylinder, and during charging operations it passes directly through the receiver manifold to the receiver cylinders.

The automatic pressure governor, which controls the compressor in order to keep the pressure in the reservoir cylinder between the desired limits of 2,000 to 2,200 p. s. i., is connected into the oxygen path at a point immediately before the reservoir manifold.

The automatic pressure controller, designed for the electric motor or gasoline engine is adjusted at the factory to actuate the compressor unit whenever the pressure within the reservoir falls to 2,000 p. s. i., and to stop the compressor when the pressure in the reservoir rises to 2,200 p. s. i. A frangible-

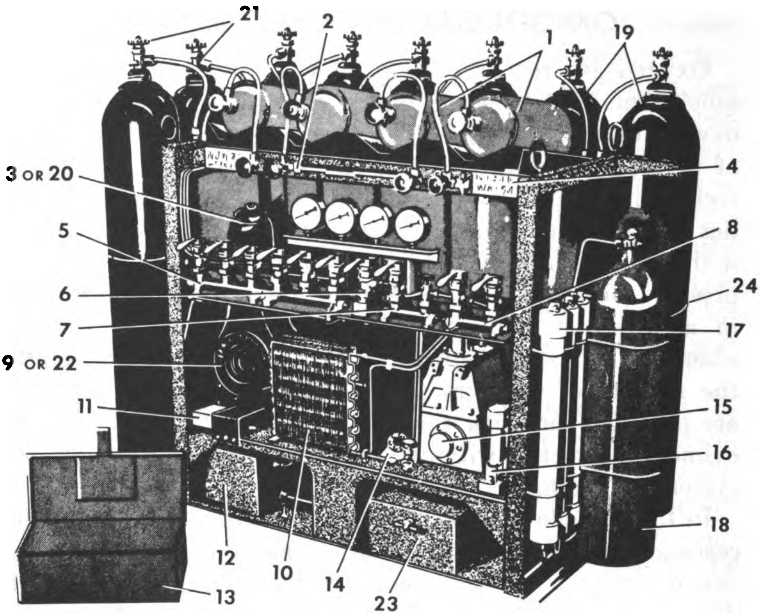


Figure 7–1.—Oxygen recharge equipment (Walter Kidde), gasoline engine and electric motor power-driven models.

1. Aircraft cylinders.
2. Receiver manifold.
3. Air filter for engine.
4. Schematic nameplate.
5. Cascade manifold.
6. Cascade master valve.
7. Reservoir manifold.
8. Supply manifold.
9. Gasoline engine.
10. Radiator.
11. Pressure controller.
12. Water tank.
13. Spare parts box.
14. Indicator.
15. Compressor.
16. Water trap.
17. Driers.
18. Reservoir cylinder.
19. Supply cylinders.
20. Motor controller.
21. Cascade cylinders.
22. Electric motor.
23. Spare parts drawer.
24. Clamping cable.

disk safety unit is connected to the oxygen path between the aftercooler and the water trap. Its purpose is to protect the compressor system from excessive pressures.

Water Path

The oxygen must be cooled to avoid high temperatures after it passes through the compressor. The cooling is done by circulating water. Water is pumped from the water tank

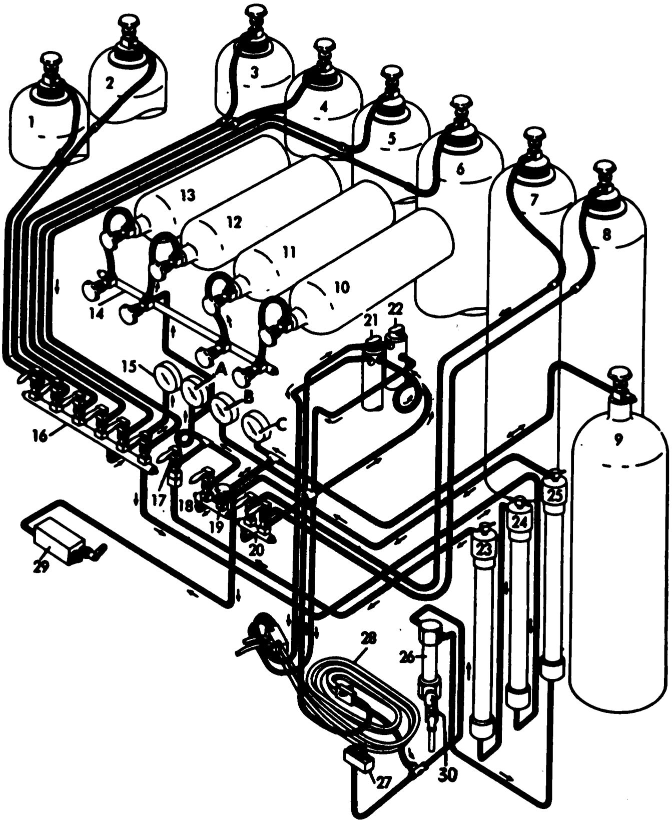


Figure 7–2.—Oxygen path in the oxygen recharge equipment.

1–6.	Cascade cylinders.
7–8.	Supply cylinders.
9.	Reservoir cylinders.
10–13.	Aircraft cylinders.
14.	Receiver manifold and valves
15.	Pressure gage (Cascade cylinder).
15A.	Pressure gage (Receiver cylinder).
15B.	Pressure gage (Supply cylinder).
15C.	Pressure gage (Reservoir cylinder).
16.	Cascade manifold and valves.
17.	Cascade master valve.
18.	Reservoir master valve.
19.	Reservoir shutoff valve.
20.	Supply manifold and valves.
21.	Low-pressure compressor.
22.	High-pressure compressor.
23–24.	Cascade driers.
25.	Compressor drier.
26.	Water trap.
27.	Safety unit.
28.	Cooler.
29.	Pressure controller.
30.	Water trap blowoff valve.

through the aftercooler and the intercooler. It then flows through the water flow indicator to the low- and high-pressure cylinders of the compressor, where it passes through lanterns surrounding the plungers, acting as a lubricant as well as a coolant, and thence returning to the tank through a radiator. A bypass valve is inserted in the system to return water from the pump directly to the tanks. By adjusting this valve, the rate of flow through the cooling system can be regulated. (See figs. 7–2 and 7-3.)

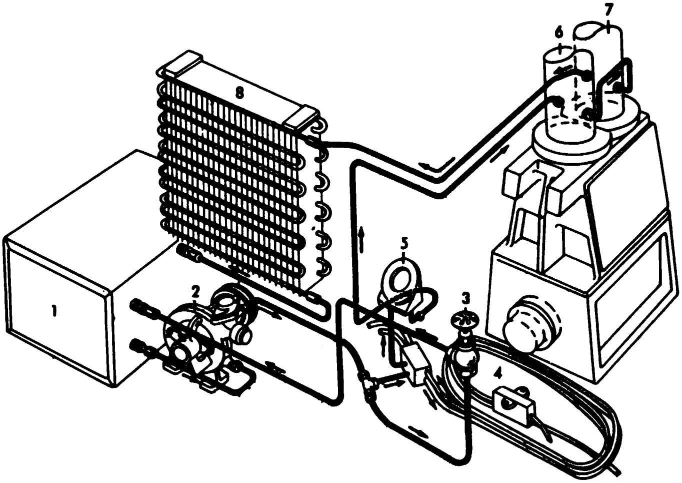


Figure 7–3.—Water coolant circulation in the oxygen recharge equipment.

1. Water tank.
2. Water pump.
3. Bypass valve.
4. Cooler.
5. Flow indicator.
6. Low-pressure compressor.
7. High-pressure compressor.
8. Radiator.

Initial Preparation for Use

When using the gasoline-powered recharge equipment, fill the crankcase of the engine with a high-grade oil (not heavier than SAE No. 20). The crankcase holds 3 pints. Fill the air cleaner to the indicated oil level with the same oil as is used in the crankcase. Fill the gas tank with good, fresh clean gasoline. Do not mix oil and gasoline.

When using electrically-powered models be sure that the connections to the power supply are correctly made and that the current supply is that prescribed for the unit.

Check the oil level in the crankcase of the compressor. Inspect the oil for water. If water or sediment appears, drain and refill with No. 20–W oil ONLY until the level is between the two lines on the oil gage on the left-hand side of the compressor crankcase. KEEP OIL OFF THE REST OF THE EQUIPMENT.

Fill the water tank to approximately a 7-inch depth with clear, fresh water. Then open the water bypass valve (3, fig. 7–3) all the way. After the compressor starts, this valve should be adjusted to permit the water to flow at a rate which barely blends the two colors on the disk (5, fig. 7–3) of the water flow meter.

Loosen the bolts holding the flywheel support blocks (fig. 7–4) and draw the blocks back until they are clear of the flywheel hub. Then retighten the bolts. Turn the flywheel (fig. 7–4) by hand to make sure it revolves freely.

See that all valves on the front of the framework are

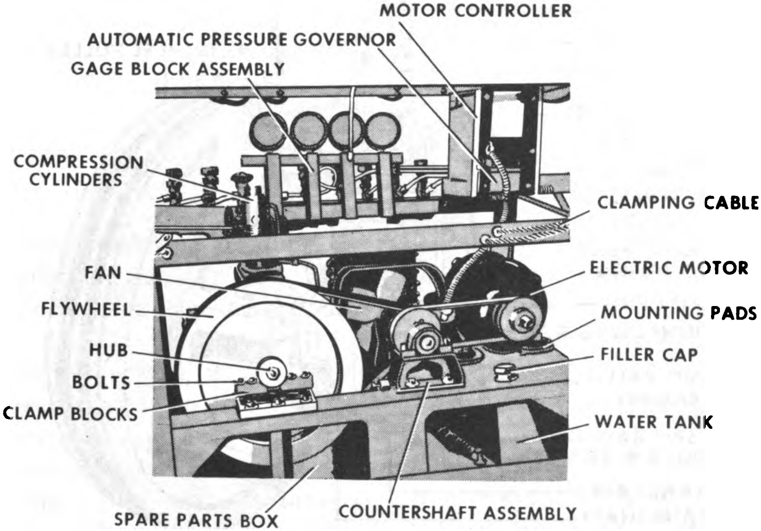


Figure 7–4.—Rear view of electrically-powered machine.

closed and that the water trap blowoff valve (fig. 7–6) is open.

Remove the compressor cylinder valve caps and both intake valves of the high- and low-pressure cylinder assemblies. Fill the space above the plungers (compression chamber, fig. 7–5) with water to within one-half inch of the top. Run the compressor for 45 minutes before REMOVING THE WATER AND REPLACING THE VALVES AND CAPS. This will condition the packing (fig. 7–5) in the cylinders by forcing the water into the packing and lubricating them.

Remove the caps, inner retainer caps, and filters on the driers. (See fig. 7–7). If the equipment is new, the drier cartridges must be filled with the drying agent. If the equipment is old, the indicator crystals with the drying

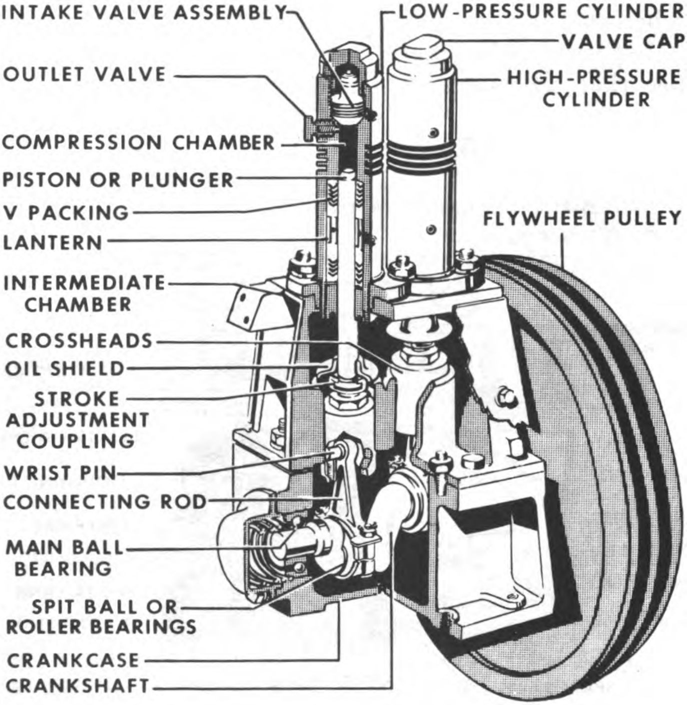


Figure 7–5.—Cutaway view of recharge compressor.

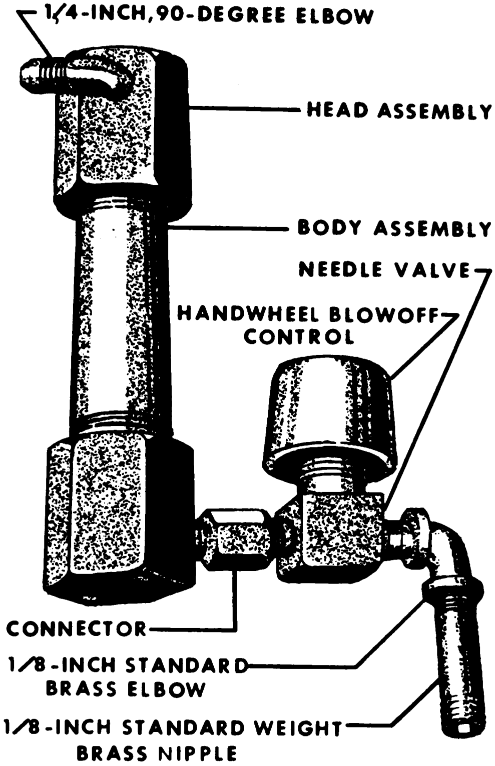

1/4-INCH, 90-DEGREE ELBOW
HEAD ASSEMBLY
BODY ASSEMBLY
NEEDLE VALVE
HANDWHEEL BLOWOFF CONTROL
CONNECTOR
1/8-INCH STANDARD BRASS ELBOW
1/8-INCH STANDARD WEIGHT BRASS NIPPLE

Figure 7–6.—Water trap.

compound may be pink, showing that the drier has lost its effectiveness and must be replaced. Refer to the section on DRIERS appearing later in this chapter.

DO NOT REMOVE THE PROTECTIVE CAPS FROM THE ENDS OF THE FLEXIBLE METAL TUBES ATTACHED TO THE TOP OF THE FRAMEWORK UNTIL THE SUPPLY CYLINDERS AND RECEIVER CYLINDERS ARE TO BE CONNECTED TO THEM. Once these coverings are removed, dirt or foreign matter may get into the tubes and contaminate the oxygen. These tubes (flexible metal hose) must always be connected to a cylinder valve or plugged so that foreign matter cannot get into them. If dirty, they should be cleaned with trichloroethylene.

Operating Instructions

Before starting a charging run of the recharge equipment, the pressure in the reservoir must be raised to approximately 2,200 p. s. i. This is done as follows:

1. Close ALL valves (including the water trap blowoff valve, fig. 7–6) except the water bypass valve (3, fig. 7–3) which has been previously adjusted during the conditioning of the equipment.

2. Place one standard 220-cubic foot oxygen supply cylinder in each of the eight rack spaces provided at the left-hand end and at the back of the framework as shown in figure 7–2. Clamp these cylinders in place with the clamping cables provided (24, fig. 7–1). Henceforth, each cylinder will bear the name designated by the nameplate immediately next to its rack position. Connect the eight flexible tubes on the top of the framework to these cylinders and open the valves of these cylinders.

3. Open the reservoir cylinder valve (9, fig. 7–2). This valve is normally open, and is closed only in case of emergency, for replacement or inspection of the drier chemical, or when the recharge equipment is to be shut down. It is also closed when repairs are to be made to the compressor or to the automatic pressure controller.

4. Open the reservoir manifold marked RESERVOIR SHUT-OFF VALVE (19, fig. 7–2). This valve is also normally open and is closed only at such times as the reservoir cylinder valve is closed.

5. Open the valve on the supply manifold SUPPLY CYLINDER NO. 1 (7, fig. 7–2) and observe the reading on the supply pressure gage (15B, fig. 7–2). Wait for a stabilized gage reading before taking the next steps. During charging operations this reading will drop. When it is at approximately 300 p. s. i., the SUPPLY CYLINDER NO. 1 valve should be closed and the valve marked SUPPLY CYLINDER NO. 2 should be opened (8, fig. 7–2). SUPPLY CYLINDER NO. 1 (7, fig. 7–2) should then be removed from the rack and re-

placed with a new cylinder. In the same way SUPPLY CYLINDER NO. 2 should be replaced when its charge drops below 300 p. s. i. The supply cylinders may be fully charged cylinders or partially exhausted cylinders from previous operations, just so the pressure in each is well above 300 p. s. i.

6. On electric-powered units merely set the motor-control switch on AUTOMATIC OPERATION (located on the controller unit door) and the compressor will start. On the gasoline-powered units it is necessary to start the engine or, if the engine has been idling, to advance the hand throttle until the clutch engages and the compressor starts.

7. The compressor will run until the reservoir cylinder is charged to approximately 2,200 p. s. i.; then the automatic controller will shut off the power. When this occurs, the recharge unit is ready for charging operations.

8. While the compressor is in operation, open the water trap blowoff valve every 15 minutes. Hold it open until all trapped water is discharged from the valve.

STARTING THE GASOLINE ENGINE.—The gasoline engine is started as follows:

1. Open the gasoline shutoff valve in the gas filter. Completely close the carburetor choke.

2. Slip the knotted end of the starter rope into the notch of the starter pulley and wind the rope around it. Pull the rope with a quick, steady pull.

3. Gradually open the choke valve until the engine runs smoothly with the choke valve wide open.

CHARGING RECEIVER CYLINDERS.—All the steps in the actual charging of aircraft cylinders are performed from the front of the recharge unit. The cylinders of the cascade system racks and the supply racks can be changed during charging operations. The receivers or aircraft cylinders should be changed only when all manifold and cylinder valves are in the same condition as they were at the end of the preparation for charging the first cylinder. This procedure is as follows:

1. All valves on the cascade manifold are closed (16, fig. 7–2).

2. The CASCADE MASTER VALVE is closed (17, fig. 7–2).

3. The RESERVOIR MASTER VALVE is closed (18, fig. 7–2).

4. The RESERVOIR SHUTOFF VALVE is open (19, fig. 7–2).

5. Either the SUPPLY CYLINDER NO. 1 valve or the SUPPLY CYLINDER NO. 2 valve is open, the other being closed.

6. The RESERVOIR CYLINDER VALVE is open.

7. The WATER TRAP BLOWOFF VALVE is closed (30, fig. 7–2).

8. All valves on the receiver manifold are closed (14, fig. 7–2).

9. All valves on the cascade cylinders (1, 2, 3, 4, 5, and 6, fig. 7–2) and supply cylinders (7 and 8, fig. 7–2) are open.

Place the receiver cylinders on the racks on top of the framework with the valves to the front of the unit, and attach the flexible metal tubes connected to the handwheel-operated valves on the receiver cylinders.

1. Open the valves on the receiver cylinders.

2. Open the valves on the receiver manifold. IF FEWER THAN FOUR CYLINDERS ARE TO BE CHARGED, DO NOT OPEN ANY MANIFOLD VALVE WHICH DOES NOT HAVE A CYLINDER CONNECTED TO IT.

3. Open the CASCADE MASTER VALVE.

4. Open the cascade manifold valve marked CASCADE CYLINDER NO. 1 and observe the pressure reading on both the cascade pressure gage and the receiver pressure gage. When the fluctuations have stopped and the readings are the same, the pressures in the aircraft cylinders and in the cascade cylinder have been equalized. Close the CASCADE CYLINDER NO. 1 valve and open the valve marked CASCADE CYLINDER NO. 2. Observe the readings as before. When the pressure has been equalized, close the CASCADE CYLINDER NO. 2 valve and open the CASCADE CYLINDER NO. 3 valve. Proceed as before with the other valves on the cascade manifold until all have been used or until the pressure in the receiver cylinders reaches 1,900 to 1,950 p. s. i.

NOTE: The final pressure desired in the cylinders is 1,800 p. s. i., but the heat of compression expands the gas and makes it necessary to charge the receiver cylinders to the higher pressure, 1,900 to 1,950 p.s.i. For greater accuracy the rule of ±5 p. s. i. for every degree above or below 70° F. may be applied, but for most operations under normal conditions, filling to 1,900 to 1,950 p. s. i. is a sufficient temperature adjustment.

5. Make sure the sliding indicator under the cascade manifold points to the cascade cylinder valve connected to the cylinder with the lowest pressure. When setting up the operation, this cylinder should always be connected to the CASCADE CYLINDER NO. 1 valve; that with the next lowest pressure connected to the CASCADE CYLINDER NO. 2 valve; that with the next lowest to the CASCADE CYLINDER NO. 3 valve, etc. The cylinder having the greatest pressure is connected to the CASCADE CYLINDER NO. 6 valve. To check the pressure of each cylinder, open the valve on the manifold which is connected to the cylinder and read the pressure on the cascade pressure gage connected to the cascade manifold.

6. During the charging operation, the pressure in the CASCADE CYLINDER NO. 1 will drop below 600 p.s.i. At this time disconnect this cylinder and replace it with a fully charged cylinder. Move the sliding indicator over until it points to the CASCADE CYLINDER NO. 2 valve. This valve then becomes the first to be opened in subsequent cascading operations until such time as the cylinder connected to it drops to less than 600 p. s. i. pressure; then this cylinder is replaced and the indicator moved over to point to the CASCADE CYLINDER NO. 3 valve. This, in turn, becomes the first to be opened. Similarly, the slider is moved over whenever a cylinder is changed, and the slider should always point to the valve connected to the cylinder containing the lowest pressure, which is always the first cylinder to be used in cascading operations.

7. Perform the cascading operation by opening the valve on the cascade manifold in rotation. Start with the one to which the slider points, and proceed to the right-hand end of the manifold. Then start at the left-hand end and continue until the valve immediately to the left of the slider is opened and closed.

NOTE: Only one valve on the cascade manifold should be opened at any time, and it must always be closed before the next valve is opened. If not, the equalization will take place between the cylinders in the cascade system as well as with those connected to the receiver manifold, and a considerable amount of time will be lost correcting this condition.

TOPPING-OFF THE RECEIVER CYLINDERS.—If the cascading operation does not charge the receiver cylinders to the desired pressure, perform the topping-off operation as follows:

1. Close the CASCADE MASTER VALVE.

2. Open the RESERVOIR MASTER VALVE on the reservoir manifold. Compare the readings on the reservoir pressure gage and on the receiver pressure gage. When the charge in the receiver cylinder reaches the desired pressure, close the RESERVOIR MASTER VALVE. Close all valves on the receiver manifold and all receiver cylinder valves. This will leave all valves in the condition described under CHARGING RECEIVER CYLINDERS, and the recharge equipment is ready to start a new cycle of operation. That is, of course, after the now-charged aircraft cylinders have been removed and replaced by other cylinders to be filled.

CHARGING CYLINDERS DIRECTLY FROM THE COMPRESSOR.—If it is desired to charge the cylinders directly from the compressor without using the cascading system, the receiver cylinders should be connected to the receiver manifold as before.

1. Close the valve on the reservoir cylinder.

2. Be certain that the CASCADE MASTER VALVE is closed.

3. Make certain that the RESERVOIR SHUTOFF VALVE is open. See that either the SUPPLY CYLINDER NO. 1 valve or the SUPPLY CYLINDER NO. 2 valve is open, as in normal charging operation. These cylinders may be changed during the charging operation in the manner described previously, but care should be taken to see that the compressor always has an adequate supply of oxygen.

4. Open the RESERVOIR MASTER VALVE.

NOTE: The receiver pressure gage must be watched very closely during all direct charging operations to prevent building up excessive pressures. The recharge equipment is protected against damage by a safety disk connected to the compressor system, but excessively high pressures have a tendency to dry out the packing in the compressor cylinders and to shorten its life.

5. When the receiver cylinders have been charged to the desired pressure, STOP THE COMPRESSOR BEFORE CLOSING ANY VALVES. This can be accomplished by reducing the gasoline engine's speed to idling by hand control or by stopping the electric motor.

6. Close the valves on the receiver cylinder manifold.

7. Close the valves on the receiver cylinder and remove the cylinders from the rack.

8. Close the RESERVOIR MASTER VALVE.

9. Open the valve on the reservoir cylinder. The recharge equipment is now ready to resume normal operation.

CONSOLIDATING PARTLY EMPTY CYLINDERS.—When many cylinders must be charged in a short period, time can be saved by using fully charged ones as the supply cylinders for the compressor instead of using those partly emptied during the cascade operations. This will result in faster restoration of the topping-off pressure in the reservoir, but will accumulate a quantity of partly charged cylinders. The consolidation procedure follows:

1. First, see that all valves are in the same condition as described for the start of normal operations.

2. Connect eight partly charged 220-cubic foot cylinders to the racks at the left-hand end and at the back of the framework. Do NOT connect any cylinders to the reservoir manifold valve.

3. Open the SUPPLY CYLINDER NO. 1 valve.

4. Start the engine or electric motor on automatic control. Although the reservoir cylinder is not used to top off the cylinders which are being charged, it serves as a buffer and accumulator as well as a control for the power unit. Without it, or with the reservoir cylinder valve closed, the charging operation must be performed under hand control.

5. Open the RESERVOIR MASTER VALVE.

6. Open the CASCADE VALVE.

7. Open the CASCADE CYLINDER NO. 1 valve and check the pressure on the cascade pressure gage. When the pressure rises to the desired level (the same as that of a fully charged

supply cylinder), close the CASCADE CYLINDER NO. 1 valve and open the CASCADE CYLINDER NO. 2 valve. Proceed until all the cylinders connected to the cascade manifold are fully charged.

8. During this operation the compressor supply cylinders will have to be changed frequently. While the compressor is operating this can be done in the same manner as during normal charging operations. As soon as any cylinder connected to the cascade manifold is fully charged, it can be removed and replaced by a semicharged cylinder. In this manner, it is possible to avoid having to store a large number of partly filled cylinders.

9. This consolidation process is the only one which calls for both the RESERVOIR MASTER VALVE and the CASCADE MASTER VALVE being opened at the same time. To have them both open at the same time during normal charging operations would result in using the reservoir cylinder and the compressor to charge the cascade system as well as the receiver cylinder.

10. When the consolidation is completed, restore all valves to the original condition in preparation for normal charging operations.

The following shutdown procedure will guard the equipment against possible damage:

1. Close the valves on all cylinders in place on the racks at the left-hand end at the back of the framework.
2. Open all valves on the cascade manifold.
3. Open the CASCADE MASTER VALVE.
4. Close the valve on the reservoir cylinder.
5. Open the WATER TRAP BLOWOFF VALVE.
6. Open the RESERVOIR MASTER VALVE.
7. Open the RESERVOIR SHUTOFF VALVE.
8. Open the two valves on the supply manifold.
9. Close all valves on receiver cylinders connected to the receiver manifold.
10. Open all valves on the receiver manifold. If there is any flexible tube leading from one of the valves which does not have a cylinder connected to it, either connect a cylinder

or a suitable cap to prevent the possible entry of foreign matter into the tube.

11. Run the compressor for 15 minutes under hand control before shutting down the power unit. This will lubricate the packing and lengthen its life. Run the machine in the same way without pressure before resuming charging operations.

12. Shut off the power unit.

The purpose of all this is to leave the tubing and other parts interconnected and permit discharging through the water blowoff trap. This prevents building up excessive pressures due to room temperature changes or other causes. It also relieves the safety disks so that they will not rupture without the knowledge of the operator and later cause trouble when charging operations are resumed.

EMERGENCY SHUTDOWN.—Treat any unusual condition as an emergency to be investigated only after the machine is rendered safe. When an emergency arises while the equipment is in operation, carry out the following procedures as rapidly as possible:

1. Stop the motor or engine.
2. Open the water trap valve.
3. Close valves on the supply cylinders.
4. Close valves on the receiver cylinders.
5. Close valves on the cascade cylinders.
6. Close valves on the reservoir cylinders.
7. Open all manifold valves.

Maintenance

Before attempting repairs or adjustments of this equipment, study the maintenance instructions in the *Handbook of Operation Service and Overhaul Instructions with Parts Catalog—Oxygen Recharge Equipment Models X-4438 and X-4439 (Walter Kidde) AN 19-5-17*. Be certain each step is thoroughly understood before proceeding to do the work. All repairs and adjustments should be made under the supervision of a qualified operator.

As an example of maintenance procedure, we can focus attention on the driers, but other items, such as the cooling system, compression cylinder valves and packings, water trap, safety disks, automatic pressure controller on model X–4438, and the manifold valves, all require a certain standard of maintenance which is outlined in the appropriate section of the handbook.

As an example of maintenance procedure, we might single out the driers for a brief discussion since they require operating attention and maintenance of a specialized sort.

DRIERS.—The chemical agent for the drying towers is supplied in 1-pound cans, each of which will fill one drying cartridge. The removable cartridge contains a filter composed of 10 layers of monel mesh. This filter prevents particles of the drying agent and indicator from getting into the oxygen lines (fig. 7–7).

The indicator is furnished in 1-ounce bottles, each holding enough for one cartridge. The indicator turns pink when the chemical has lost its drying capacity. When this happens, the entire drying charge should be replaced.

To refill the cartridge, remove the top cap of the drier, the inner cap, and the filter; then lift out the cartridge. Empty the used chemical and indicator and clean the cartridge in water. Rinse it in pure trichloroethylene and allow to dry by evaporation. Fill the cartridge with drying agent to within about one inch of the top. Fill the remaining portion with the indicator. Replace the cartridge filter and inner cap. Check the packing ring for abrasion, replacing it if necessary before reassembling the cap.

The drying agent and indicator can be reactivated by spreading them in a shallow pan and heating them to a temperature between 350° and 600° F. Heating to a high temperature destroys some of the effectiveness of the material, so carry on the reactivation near the lower temperature of 350° F. even though it takes a little longer.

If the filter becomes clogged, remove it, disassemble it, and wash it in clear water. Then wash it in trichloroethylene and allow it to dry by evaporation before putting it back in the dryer. DO NOT CLEAN THE FILTER BY BLOWING COMPRESSED AIR THROUGH IT. Oil might be deposited in the mesh.

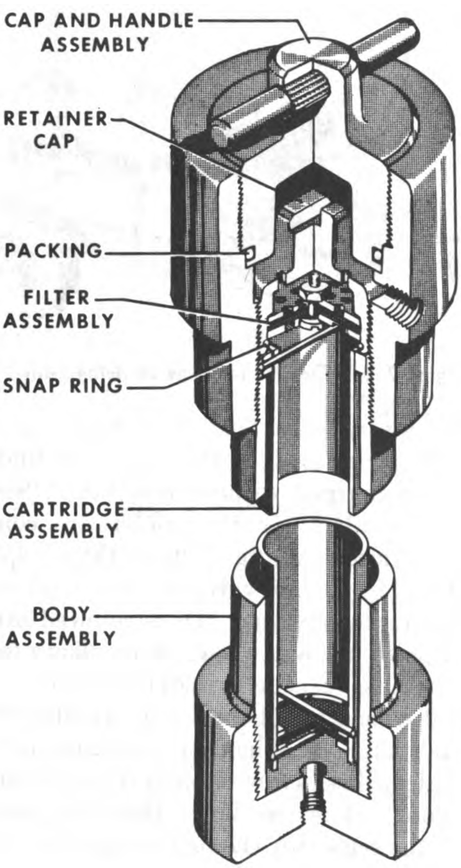


Figure 7-7.—Cutaway view of drier.

OXYGEN RECHARGE SERVICING TRAILER

The frequency of high altitude flights has made the development of portable servicing trailers imperative. One of the most popular types used in naval aviation is the standard multiple cylinder trailer listed in the ASO catalog. This gaseous oxygen recharge equipment is used to provide a means of recharging aircraft supply cylinders installed in the aircraft. The oxygen storage (cascade) cylinders and flow controlling mechanism can be towed to the aircraft for

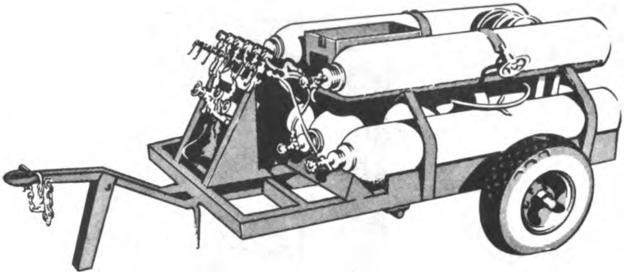


Figure 7–8.—Oxygen recharge servicing trailer.

servicing. By means of a flexible high-pressure hose and applicable fittings and valves the supply cylinders in the aircraft can be recharged without removal. (See fig. 7–8.)

The supply cylinders for the trailer are connected by means of flexible hoses ((A) fig. 7–9) to their respective control valves (B). The control valves are fastened to the upper manifold (C). A pressure gage (D) is screwed into the control valve at a point below the seat which allows for the reading of the respective cascade cylinder pressure. The manifold is provided with a fusible metal safety plug which melts at approximately 212° F. When the fusible metal has melted, the frangible safety disk is free to burst if the pressure reaches the danger point. The gas flows from the manifold (C) either through the regulator (E) or through the bypass valve (F), or both. The gas is then collected in the lower manifold (G), and the pressure at this point can be read by the gage (H) on this manifold. The lower manifold is connected by flexible hose (I) to a drier (J) which filters the oxygen. The recharging hose (K) connects directly to the drier and has a line valve (L) on the terminal end. This line valve is fitted with the standard oxygen cylinder connection.

Adapters are provided for charging through check valves and through low-pressure filler valves. Recharge from the cascade supply cylinder of the lowest pressure first; that is, the lowest pressure that is greater than that of the aircraft's system. When there is no longer any flow of gas (when lower manifold gage is within 15 p. s. i. of the cascade supply

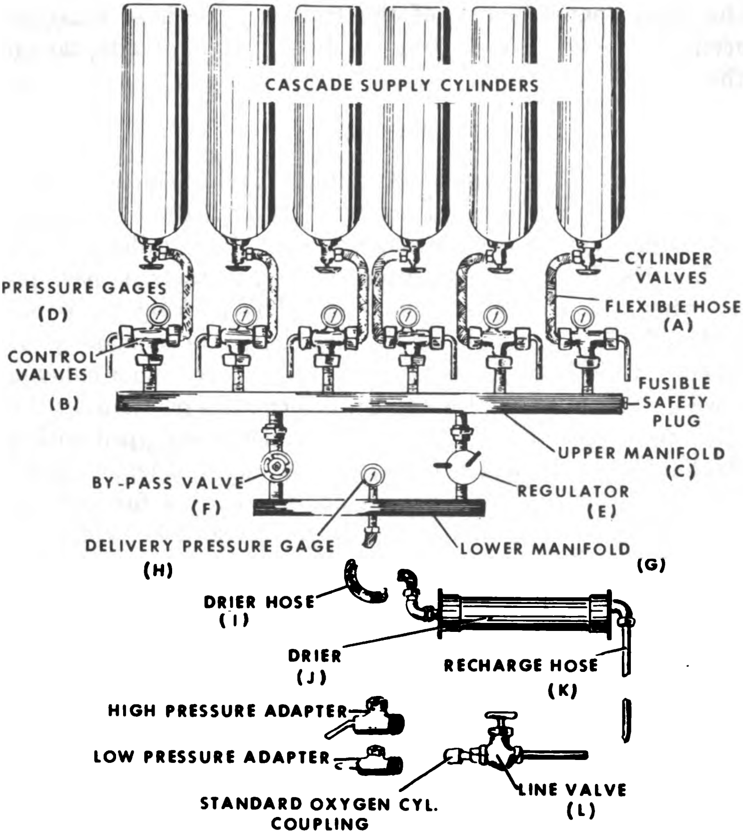


Figure 7–9.—Flow diagram for servicing trailer system.

cylinder gage), use the cascade supply cylinder with the next lowest pressure. Work the cascade cylinders in the order of their pressure until the system being recharged has reached the desired pressure. Using the lowest pressure first and working to the highest allows for the most efficient use of the oxygen. When the system is completely charged, close the line valve tightly before removing connections. After removing connections and securing the filler valve of the aircraft, place the hose valve in the pocket on the hose reel drum. The hose is wound over the top of the reel toward the front (panel board) of the trailer. The hose must be secured snugly. Never drag the hose, valve, or adapter on the ground.

Description

TRAILER.—The two-wheel, rubber-tired vehicle is designed to adequately transport six ICC3AA 2,400 p. s. i. oxygen storage cylinders over rough terrain. The trailer is fitted with a drawbar which is supported by a retractable parking leg when the trailer is uncoupled. The parking leg is attached by a pivot bolt to the drawbar, and swings up or down. A pin latch holds the leg up when the trailer is being towed. When uncoupled the leg is locked in position by the offcenter weight distribution. The trailer is equipped with a mechanical brake which is operated by a hand lever on the right-hand side. These brakes are to be used for parking only, and are not to be relied upon for bringing the trailer to a sure stop. When the trailer is used aboard ship in lieu of the ship's oxygen transfer system, extra care must be taken to prevent it from rolling off the flight deck or damaging parked aircraft. If a tractor is not available to haul the trailer, extra men may be employed to pull it. However, appropriate wheel chocks must be available to bring or hold the trailer to a standstill. The trailer has a lunette eye on its drawbar for towing which can be coupled to a maintenance vehicle by a pintle hook.

HANDWHEEL AND LEVER TYPE VALVES.—The valves on the cascade cylinders are the handwheel type while the six manifold control valves are the lever-operated type, and serve to control the flow of gas from the cascade cylinders to the cylinders being charged.

BYPASS AND LINE VALVES.—A bypass valve, used under emergency conditions, is a straight on-and-off valve of a packless globe type construction. The line valve at the end of the recharge hose is similarly constructed.

OXYGEN DRIER.—The drier is essentially a reservoir containing a chemical drying agent through which oxygen must pass before going through the charging hose. The drier removes moisture which might adhere to the valves or is accidentally admitted into the system while making connections. Oxygen flows into the bottom of the drier, passes up through the drying agent past the indicating chemical, and out through the recharging hose.

Flexible metallic hose.—Short lengths of this type hose connect the cascade cylinders to each of the control valves on the upper manifold. These hose will withstand more vibration and normal abuse than copper tubes.

Recharging hose.—The recharge hose with valve attached to one end is also a high-pressure nonkinking metallic flexible hose. It is rubber covered for protection and is designed to withstand more wear than the shorter metallic hose connecting the cascade cylinders to the control valves.

Hose reel.—The hose reel is manually operated and is equipped with a locking mechanism. The locking lever is opened when it is UP and locked when it is DOWN. When DOWN, it is under tension. For those operators who do not wish to use the hose reel and simply coil the recharge hose down between the two top cylinders, some means of securing the loose end of the hose must be provided. For example, passing the line valve through a sling attached to the cart's structure will adequately hold the hose in place.

Balanced pressure regulator.—For an explanation of how this mechanism operates, see chapter 2 concerning regulators.

Low-pressure adapter fitting.—This fitting is provided for charging through a low-pressure oxygen filler valve. The adapter incorporates a safety disk which will rupture at approximately 476 p. s. i.

High-pressure adapter.—This adapter is provided to charge through a check valve having a 5/16-inch tube end fitting. A plug protects the coupling nut and nosepiece with this adapter. Incorporated in the adapter is a safety disk which will rupture at approximately 2,150 p. s. i.

Loading cascade cylinders.—The trailer should be loaded with cascade cylinders while fastened to a towing vehicle. If a towing vehicle is not available, the rear stand should be let down and the handbrake applied so the weight of the cylinders will not cause the trailer to tilt backwards. The front stand will be down if the cart is not hooked to a towing vehicle; when hooked, it may remain retracted. Before installing the cylinders, check each one for a full charge and operation of the handwheel valve. To check, connect a pressure gage to the outlet of each cylinder. Open the valve completely, observing the action of the valve and registered pressure. When satisfied that the valve operates smoothly and the cylinder contains a full charge, disconnect the copper line and gage and replace the safety cap.

Cylinders should be loaded from the rear and should only be handled with safety caps in place. Standing cylinders should be brought to within four feet of the back end of the trailer. If cylinders are lying down, the safety cap end of the cylinder should be just below the rear of the trailer. The safety cap end should be lifted or lowered, as the case may be, and placed in the appropriate channel. Raising the bottom of the cylinder, work it into place. As soon as the cylinders are in place, the clamping arrangement should be tightened. The four bottom cylinders are clamped in pairs by a wheel, and the two top cylinders are tightened by a single clamp for each one.

After the cylinders are secured, the flexible metallic hose which connects each cylinder to their respective control valves on the manifold should be tightened to the cylinders. After tightening the coupling nuts, the hose should be free of torsional (twisting) strain. This strain can be prevented by gripping the hose with one hand and twisting it in the opposite direction. When the nut becomes tight, the hose will twist slightly as it seats, and will stop approximately at its natural position.

Operational Safety Precautions

The safety precautions involved in the use of the standard recharge trailer follow:

1. Keep the regulator bypass valve closed and safety wired to prevent it from being accidentally opened. This valve is intended for emergency use in the event the pressure reducer becomes inoperative and a replacement is not immediately available.

2. When recharging is in progress, a qualified operator shall be stationed at the trailer in order to observe the gages and operate the valves. A basic prerequisite to safe operation requires a thorough understanding of the trailer and the principles involved in expanding gases and aircraft oxygen systems.

3. The recharge hose and aircraft connection fittings shall be inspected prior to servicing. Any trace of oil, grease, or foreign matter must be carefully removed.

4. Never recharge an oxygen system without the adapter with safety disk incorporated in the recharge line. Identical safety disks are used in both high- and low-pressure adapters. The safety disk rupture pressure is determined by the AREA of the disk supported in the adapter. The adapter assemblies are designed so that they cannot be interchanged; therefore, only the correct assembly is compatible with the aircraft system to be serviced.

5. The recharge hose should always be BLED to insure expulsion of all loose foreign matter from the line PRIOR to connection with the aircraft system.

6. Open all valves SLOWLY. When using an oxygen recharge trailer for servicing aircraft systems, the dangers of rapid cascading must be avoided. The acceleration and resultant high heat generated cannot be carried off fast enough in the heavier metal of the check valves. This condition can cause rust or oxidation of the poppet elements.

7. To insure economical use of available oxygen in the recharge trailer cylinders, the existing pressure in the aircraft system must be known; and the pressures in all the

cascading cylinders to be used in the cascading process must be known BEFORE commencing the recharge operation.

8. Insure that the line valve on the discharge end of the recharge hose is closed when not actually in use. The end of the line should be plugged to prevent moisture and foreign matter from entering.

9. Never have more than one cylinder control valve open during cascade transfer operations.

10. The charging hose should never be tightly stretched or pulled in an effort to make a connection. Move the equipment or get a longer recharging hose so that it will not be under tension while charging.

11. Never use any type hose other than the kind designed for use with high-pressure oxygen gas.

12. When a short length of 3/16-inch copper tubing is used in conjunction with discharge line-valve connections, do not bend it excessively. Bending and rebending will weaken the tubing. Change this short-line connection frequently!

13. When disconnecting the transfer hose from an aircraft filler valve, loosen the connection slowly to prevent rapid bleeding of the oxygen remaining in the line between the checks. If a check valve fails to stop the back flow of oxygen, tap it gently with a fiber or plastic object. This method is often effective in reseating a check valve.

14. In locations where hangar space is available, the trailer should be stowed inside during periods of nonuse. Where inside stowage is impractical, a canvas cover should be used to protect the manifold panel and hose assemblies.

Operation

RECHARGING PROCESS.—The cascading steps are as follows:

1. Bleed the discharge line briefly, using the "low" cylinder. Close the line valve and set the trailer's regulator pressure as follows:
    a. Close valves on regulator.
    b. Open load valve approximately ½ turn.
    c. Open cascade control valve to a higher cylinder pressure than the desired delivery pressure.

d. Carefully open bleed valve on the regulator so that gas flows through the regulator when gage on lower manifold reads desired pressure. Quickly close load valve on regulator; then close the bleed valve. (It is normal for gas to leak out of the regulator when it is open.)

e. If pressure gets higher than delivery pressure during setting procedure, bleed all pressure from hose and repeat above procedure.

f. To check the regulator setting, blow off existing pressure at the line valve. Close line valve. Open cascade control valve, having a higher setting than the desired delivery pressure. Compare gage readings.

2. Determine the pressure of the aircraft system to be charged.

3. Be certain that all six control valves are closed. If these valves are partially opened, the cascade cylinder pressure will equalize between the cylinders.

4. The line valve on the recharging hose should be closed.

5. Connect charging hose to aircraft system, and open the discharge line valve.

6. Open slowly the control valve of the cascade cylinder, having a higher pressure than the desired delivery pressure. The oxygen gas will now equalize between the cylinder or cylinders in the aircraft and the trailer's cascade cylinder that is opened on the manifold. Continue opening and closing valves slowly until the desired pressure in the system is reached. As you already know, it will be necessary to recharge the aircraft system to a higher value than 1,800 p. s. i. (in the case of a high-pressure system). Usually, 1,950 p. s. i. is a fair rule-of-the-thumb pressure to attain. This pressure figure will reduce to approximately 1,800 p. s. i. as the temperature created by cascading cools off. However, the best guide to use, and certainly the most accurate, is the temperature scale for the expansion of gases. Therefore, a Fahrenheit thermometer should be attached to the trailer as a temperature scale. When the recharging operation is completed, remove pressure from the lines of the trailer.

CHEMICAL DRIER.—The chemical drier should be inspected after every twelve cascade cylinders are used, and the chemical agent should be replaced at the first sign of the change in the indicator. The drying agent is white in color, and the indicating agent which is applied on top of the drying agent is blue in color. When moisture is present, the indicating agent will change color (from blue to pink). Inspection is easily made by removing the recharging hose and unscrewing the top cap. The drying agent can be replaced by removing the hose connecting the lower cap and lower manifold. All traces of the contaminated agent should be removed and the lower cap replaced and lower manifold hose connected. The drying agent should be quickly placed in the drier so that it does not pick up moisture from the air. Care should be given to the replacement of the indicating agent. The top cap should be screwed in place immediately after observing the condition of the indicator so that moisture or humid air does not cause the indicator to change color while the drying agent might still be very active. The caps on the drier should be screwed down until they bottom. They should be removed and replaced by hand only. The packings required in the caps of the drier called O-rings should not need to be replaced. However, if it is necessary to do so, remove the bolt holding down the porous filter material on the cap and replace with AN6227–29 O-rings. Replace filter material and bolt. (See fig. 7–10.)

MANIFOLD CONTROL VALVES.—The control valves are adjusted to be tight, but if they become loose, they can be readjusted as applied in the following steps. These valves can not be relied upon for longtime storage. (See fig. 7–11.)

1. Loosen locknut.
2. Open and close lever while gradually tightening lever assembly.
3. When feeling resistance, close valve and open cascade cylinder valve.
4. Check to see if pressure builds up on lower manifold. (Line valve on end of hose should be tightly closed.)

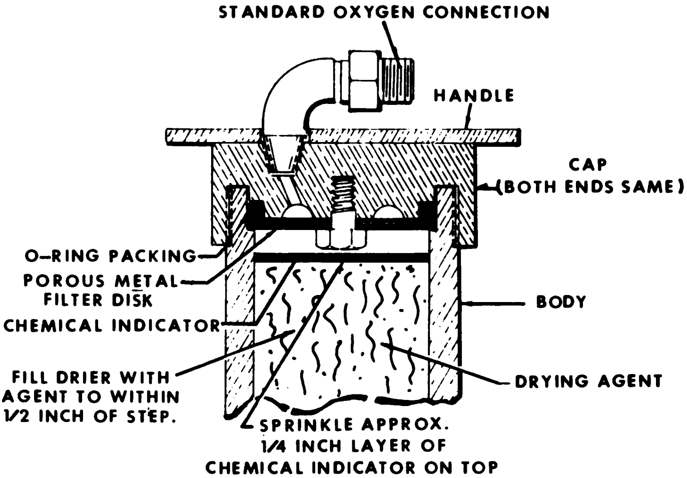

STANDARD OXYGEN CONNECTION
HANDLE
CAP
(BOTH ENDS SAME)
O-RING PACKING
POROUS METAL FILTER DISK
CHEMICAL INDICATOR
BODY
FILL DRIER WITH AGENT TO WITHIN 1/2 INCH OF STEP.
DRYING AGENT
SPRINKLE APPROX. 1/4 INCH LAYER OF CHEMICAL INDICATOR ON TOP

Figure 7-10.—Drier.

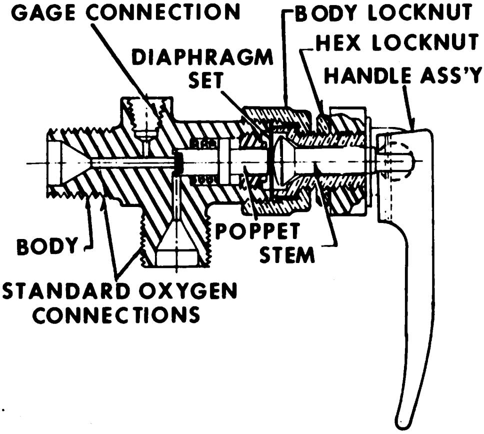


Figure 7-11.—Control valve.

5. If valve is tight, lock in place by means of locknut. If not tight repeat steps 2, 3, and 4 above.
6. Orient handle assembly by loosening locknut and rotating handle assembly and stem.
7. Retighten locknut.

LUBRICATION.—The line valve can be lubricated. When lubrication is needed, use a powdered ammonia-free graphite on the valve stem and stem head (part in contact with diaphragm). The powdered graphite may be mixed with distilled water for easy application.

DIAPHRAGM REPLACEMENT.—To replace the control valve diaphragm remove all pressure from the system. Follow the procedure outlined below:

1. Completely loosen locknut and remove handle and stem assembly.
2. Remove diaphragm.
3. Replace complete set of diaphragms putting stainless steel diaphragm toward valve body.
4. Replace handle and stem assembly.
5. Lock in place by securely tightening locknut. (See fig. 7–11.)

To replace the diaphragm of the bypass valve and line valve, follow the procedure outlined below:

1. Replace diaphragm, removing all pressure from system.
2. Unscrew handle (open valve).
3. Unscrew bonnet.
4. Remove diaphragms and replace with new set. Stainless steel diaphragm faces valve body.
5. Replace bonnet and pull up tight.

BASIC PLANT FOR LOW-PRESSURE SERVICING EQUIPMENT

All types of equipment for recharging the low-pressure oxygen system (fig. 7–12) include the following basic components:

1. HIGH-PRESSURE STORAGE CYLINDERS.—There may be two, six, or more cylinders (1), depending upon the type of servicing equipment used.

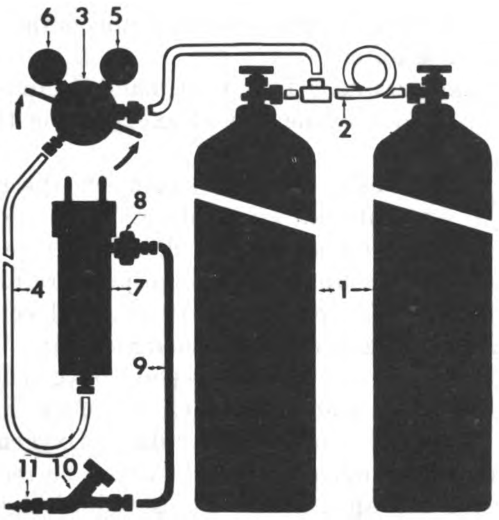


Figure 7–12.—Essential parts of a low-pressure recharger apparatus.

1. **Cylinders.**
2. **Manifold.**
3. **Pressure reducing valve.**
4. **Tube.**
5. **Cylinder pressure gage.**
6. **Reduced pressure gage.**
7. **Purifier assembly.**
8. **Filter.**
9. **Flexible hose.**
10. **Charging valve.**
11. **Adapter.**

2. MANIFOLD.—A manifold (2) connects the high-pressure cylinders to the pressure reducing valve.

3. PRESSURE REDUCING VALVE.—This valve (3) reduces the pressure of the oxygen received from the high-pressure cylinders and discharges it at a reduced pressure (determined by a hand adjustment) into a tube (4) which usually leads to a purifier. Two pressure gages are connected to the valve: one (5) shows the supply cylinder pressure; the other (6) shows the reduced pressure.

4. PURIFIER ASSEMBLY.—This assembly (7) consists of a cartridge of chemical which removes moisture from the oxygen. It is installed on the low-pressure side of the reducing valve.

5. FILTER.—This filter (8) strains out coarse particles of any kind after the oxygen has passed through the purifier.

6. Flexible hose.—This hose (9) connects the filter with charging valve adapter.

7. Charging valve.—This is a hand-operated shutoff valve (10) used to stop the flow of oxygen from the flexible hose.

8. Adapter.—This adapter (11) connects the recharging apparatus with the aircraft filler valve.

9. Conversion.—Changing the charging valve (10) and equipping it with the appropriate high-pressure fittings and a short length of $\frac{3}{16}$-inch copper tubing will convert this assembly into a high-pressure recharging rig. Therefore, the best policy is to use a high-pressure oxygen hose when installing lines (4) and (9). Such a policy makes the recharging assembly easily convertible. Oxygen bail-out cylinders and other portable cylinders may be recharged in the shop using this apparatus. The standard high-pressure servicing trailer can also be used in recharging the same items.

BAIL-OUT CYLINDER

Maintenance and Recharging

The bail-out cylinder can be recharged simply and expeditiously by using a minimum of equipment. There is no serious internal moisture problem to guard against because of its inherent design which makes use of larger orifices (holes used as passages) than found in comparative positions in breathing regulators. Excessive moisture, of course, can freeze in any size hole. Therefore, do not misinterpret the last statement. The last statement merely justifies the fact that the cylinder may be recharged without the use of a drying agent such as is found in a purifier assembly. (See step 2 of the refilling operation.) Figure 7–13 (B) illustrates the simple transfer apparatus needed to recharge the bail-out cylinder. Any high-pressure cylinder could be used as the supply source. The filling fixture and leak test cap are shown in figure 7–13 (A).

After the emergency cylinder assembly has been used, recharge it as soon as possible making it ready for service.

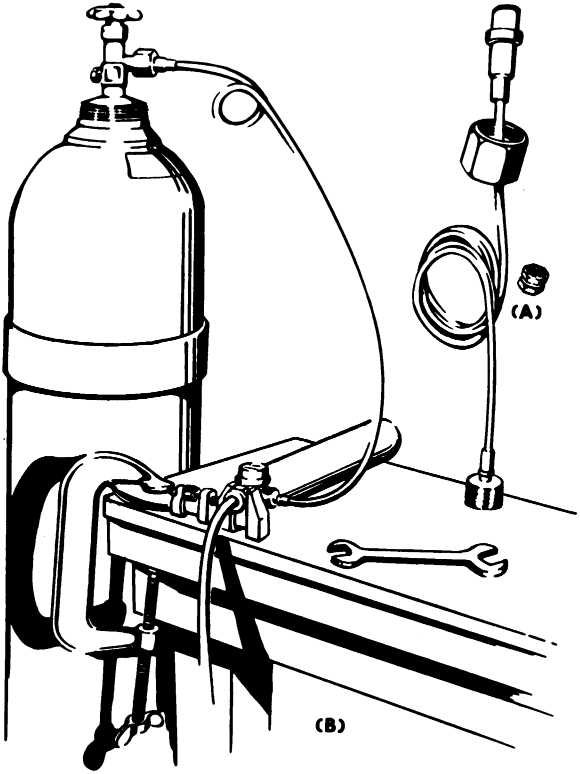


Figure 7–13.—Recharging a bail-out cylinder.

Recharging is done by using the filling fixture ((A) of fig. 7–13). A convenient arrangement for recharging the emergency oxygen cylinder assembly is also shown in figure 7–13 (B).

Caution: A tiny particle of oil coming in contact with compressed oxygen may cause a very serious explosion. Therefore, be sure hands and tools are thoroughly cleansed of all oil and foreign matter before starting maintenance work. Also, all blowing out for cleaning must be done with aviator's breathing oxygen or water-pumped dry nitrogen, not compressed air. "Water-pumped" means that the machine used to compress the gas was not lubricated with oil; therefore, no traces of oil will be in the gas. Dryness is another important factor, and unless the nitrogen gas is equally dry, as the specifications for oxygen call for the nitrogen gas cannot be used even though it was "water-pumped."

The first step in the recharging operation is the replacement of the fractured breakoff nipple. (See fig. 5–8, ch. 5.) The following sequence is used:

1. Remove the four screws (21) holding the pull cable assembly housing base (20) in place.
2. Slide the pull cable assembly down (housing (2) and attached parts) along the rubber tube (1) and out of the way.
3. Unscrew the bushing (9) from the valve body (10) and withdraw assembly of rubber tubing (1), fractured breakoff nipple (11), and bushing (9) from the valve body (10).
4. Slide the bushing (9) back three or four inches along the rubber tube (1).
5. Remove the fractured breakoff nipple (11) from the rubber tube (1), making sure that both pieces are removed if the nipple has been separated at the fracture.
6. Push a new breakoff nipple assembly (breakoff nipple (11) and O-ring (12)) into the end of the rubber tube (1) until the tube end contacts the flanged face of the breakoff nipple.
7. Grasp the rubber tube (1) just above the bushing (9) and work the bushing down around the tubing until the end of the bushing also contacts the flanged face of the breakoff nipple.
8. To drop out the valve body, the oxygen flow controller, and spring (26) invert the assembly (cylinder (25)), making sure none of these parts drop on the floor or become exposed to dirt or grease in any other way.
9. Examine the interior of the valve body (10) to make sure no foreign matter is present. If cleaning is necessary, blow out with aviator's breathing oxygen.
10. Drop the spring and oxygen flow controller back into the valve body in that sequence.
11. Screw the assembly of bushing (9), rubber tube (1),

breakoff nipple (11), and O-ring (12) into valve body (10). Screw down until all parts are together. Do not tighten.

The next step is the refilling operation of the oxygen cylinder which is done in the following sequence:

1. Connect the cylinder to be charged, making sure the charging cylinder contains only aviator's breathing oxygen. Turn bushing (9) outward one-quarter turn.

2. Crack charging cylinder valve slightly to allow oxygen to flow into emergency oxygen cylinder assembly until pressure gage (13) shows a low pressure (indicated by pointer moving not more than one-eighth inch from its zero position). Close charging cylinder valve and loosen hexagonal nut at inlet end of charging fixture to permit oxygen to escape. Retighten nut and repeat this operation twice to effect purging. Besides removing air from the cylinder, this purging method is considered sufficient for drying purposes.

3. After purging, slowly open the valve on the oxygen charging cylinder and allow the pressure in the emergency cylinder to reach about 2,000 pounds per square inch as indicated by the pressure gage (13); then close the valve on the charging cylinder. The emergency cylinder assembly will become warm during this operation and must be allowed to cool to atmospheric temperature. The emergency cylinder pressure must be checked on pressure gage (13) after assembly reaches room temperature to make sure the pressure is at least 1,800 pounds per square inch after cooling. It may be necessary to add a little oxygen at this point to make sure the emergency assembly is charged to at least 1,800 pounds per square inch and not more than 2,100 pounds per square inch.

4. Pull down bushing (9) with a torque of about fifteen pound-feet.

5. Detach filling fixture at the emergency oxygen cylinder filler nipple and replace with leak-test cap (27).

6. Check for leaks, using a mild neutral soap solution. Check at the threaded connection between valve body (10) and cylinder (25) and between valve body (10) and pressure gage (13). Check the bleed hole through the leak-test cap.

7. After being assured that all joints are tight, replace the leak-test cap (27) with dust cover (24). Recheck the indicated pressure on pressure gage (13). The reading must not be less than 1,800 pounds per square inch. Replace the pull cable assembly by sliding it over the top of the valve and secure it with the four retaining screws (21).

8. Put the caution tag and pin assembly in place through the hole provided in the housing (2).

Caution: This equipment is a precision product. Its sole value lies in its proper operation during an emergency. Refill the cylinder only with aviator's breathing oxygen. Every precaution must be taken to insure cleanliness in handling. The valve must be reassembled in accordance with instructions.

Inspection and Repair

Only visual inspection is practical. If doubt exists as to the serviceability of assemblies, replace the bail-out cylinder. It is not possible to test the valve for operating efficiency without actuating it. Therefore, testing must be confined to leak testing as previously described under the refilling operation. However, the potential user should execute the preflight inspection outlined in chapter 4 before taking off for a flight.

LIQUID OXYGEN TRAILER

The servicing trailer (fig. 7–14) is designed for storing and transferring liquid oxygen (LQOX). No LQOX trailer or storage tank once used with other liquid gases can be reused without undergoing major overhaul. The same general rules concerning gaseous oxygen in relation to contamination apply to the handling of LQOX. Once the pale blue liquid (LQOX) is exposed to a temperature higher than that required to maintain it in a liquid form or state, it expands at a rate comparable to the temperature of the environment. When warmed to ambient temperature (70° F.), it expands to about 860 times its liquid volume. Therefore, if a volume of the liquid were confined in a container or system of tubing

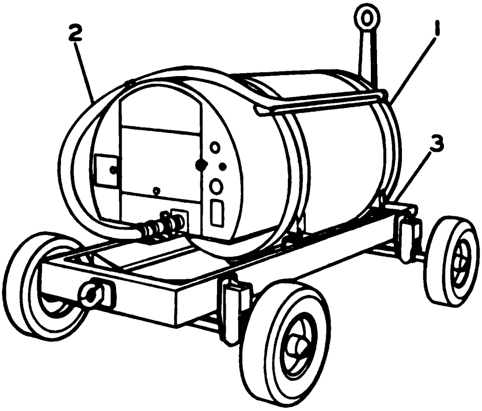


Figure 7–14.—Liquid oxygen servicing trailer (type 4, 50-gallon capacity).

1. Tank. **2. Transfer hose.** **3. Trailer.**

and were permitted to warm with no means of relieving excessive pressure, it would exert extremely high pressure (up to 12,000 p. s. i.). Consequently, LQOX must always be stored with a vent valve open.

When recharging an aircraft liquid oxygen system be certain that:

1. The aircraft is in an open area.
2. The aircraft is NOT being fueled.
3. The aircraft is electrically grounded.
4. The aircraft electrical system is OFF.
5. No APU's or starting units are connected to or operating in the vicinity of the aircraft.
6. A CO_2 fire extinguisher is immediately available.
7. Personnel keep clear of the overboard vent.
8. The deck under and in the immediate vicinity of the overboard vent is free from grease, oil, or any combustible material.

The following general safety precautions, not covered previously in chapter 5, apply to the subject:

1. Wear goggles or a face shield since liquid oxygen is very damaging to the eyes.

2. When handling parts or equipment which have been

cooled by liquid oxygen, personnel shall wear clean, dry gloves.

3. Do not carry "strike anywhere" matches in liquid oxygen handling areas.

4. In the event that liquid oxygen is spilled on clothing, the clothing should be removed immediately and thoroughly aired before being reused. If the body comes into contact with LQOX or there is reason to suspect some part of the body has been frozen or chilled, seek medical treatment immediately.

5. When transferring liquid oxygen, do not leave valves open all the way; open valves wide, then immediately close them about ¼ turn; otherwise they may freeze in the open position.

6. When transferring large quantities of liquid oxygen, insure adequate ventilation by opening doors and/or windows.

7. Handle converters, storage tanks, and transfer hose with care to avoid damage to the insulating space.

8. ALWAYS call oxygen by its proper name, OXYGEN. NEVER CALL OXYGEN AIR. Do not confuse it with compressed air. Do not lead others into such confusion by careless terminology. Never use oxygen in place of compressed air for any purpose.

9. Purge piping and equipment with dry, oil-free air or nitrogen before and after any repairs.

10. Moisture must NOT be introduced into the system. Care must be exercised to insure that no moisture is present on filler valves or nozzles where it can get into the system when they are connected.

11. Liquid oxygen spillage on floor or deck areas should be strenuously avoided. In case of accidental spillage the area should be thoroughly ventilated.

12. Never use 1,800 p. s. i. gaseous oxygen transfer equipment to transfer liquid oxygen or vice versa. Never use oxygen equipment to store or transfer any other gas or liquid.

Liquid oxygen is stored in the tank at its boiling point by controlling the heat entering the tank and thereby boiling the liquid. There is always a slight boiling action as all the heat leaking in by radiation and conduction cannot be eliminated. The gentle boiling action governs the evaporation rate or liquid loss. The evaporation rate or liquid loss by volume each 24 hours with a full tank is 3 percent for the 50-gallon tank trailer. For the 150-gallon storage tank it is 2.1 percent, and for the 500-gallon tank it amounts to 1 percent.

The tanks consist of 2 concentric cylinders separated with

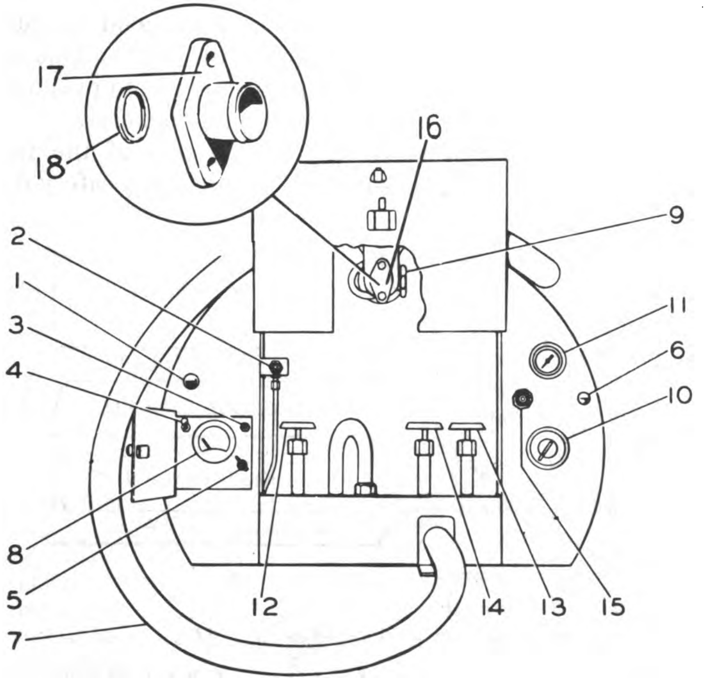


Figure 7–15.—Control hood arrangement.

1. Pressure relief vent 1.	10. Capacity gage.
2. Purging device.	11. Pressure gage.
3. Button.	12. Vent valve E.
4. Button or switch.	13. Pressure buildup valve D.
5. Knob.	14. Fill-drain valve C.
6. Pressure relief valve 6.	15. Capacity gage valve B.
7. Transfer hose.	16. Plate.
8. Thermocouple vacuum gage.	17. Vacuum pump hose fitting.
9. Vacuum valve A.	18. O-ring seal.

an 8-inch air evacuated space filled with a powdered type insulating material. While the trailer is mounted on wheels, the storage tanks (150- and 500-gallon capacity) are mounted on skids.

A vent and fill-drain line connect the external piping to the tank. These lines emerge in the control hood as illustrated in figure 7–15. A pressure relief valve (1, fig. 7–16) and a safety rupture disk (4, fig. 7–16) prevent excess pressurizing of the tank through carelessness.

A pressure buildup coil (2, fig. 7–16) is connected between the vent and fill-drain lines in the control hood on some models. In others, it extends around the unit. This coil operates as a heat exchanger and picks up heat to evaporate the liquid to pressurize the tank for liquid transfers.

A foil rupture disk is located at the rear of the tank (3, fig. 7–16) in a weather shield. This disk is a safety disk

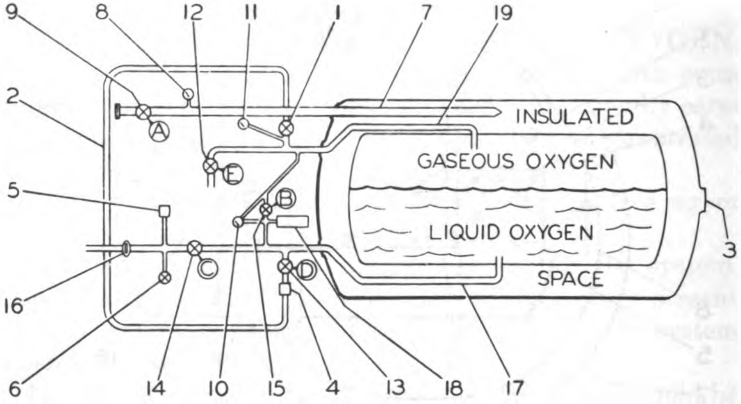


Figure 7–16.—Schematic diagram of tanks types 4, B–1 (150-gallon), and C–1 (500-gallon).

1. Pressure relief valve 1.
2. Pressure buildup coil.
3. Rupture disk.
4. Safety disk.
5. Safety disk.
6. Relief valve 6.
7. Vacuum line.
8. Thermocouple vacuum gage.
9. Vacuum valve A.
10. Capacity gage.
11. Pressure gage.
12. Vent valve E.
13. Pressure buildup valve D.
14. Fill-drain valve C.
15. Capacity gage valve B.
16. Filter.
17. Fill-drain line.
18. Dampener tank.
19. Vent line.

designed to release pressure between the tanks if the equipment is damaged. This disk must be kept intact, free from holes.

Conveniently located outside the control hood are three direct indicating gages (fig. 7–15): a pressure gage (11) for the inside tank, a differential pressure type capacity gage (10) with a bypass valve (15), and an electronic battery operated thermocouple type vacuum gage (8) to indicate the pressure in the vacuum space between the tanks. Also located on the hood are pull-test handles (1) and (6) for use with the pressure relief valves and the fill-drain coupling.

Located inside the control hood are the following items: tank pressure relief valve (1, fig. 7–15), vent valve E (12, fig. 7–15), fill-drain valve C (14, fig. 7–15), pressure buildup valve D (13, fig. 7–15), tank pressure safety rupture disk (4, fig. 7–16), hose pressure relief valve (6, fig. 7–15), and hose pressure safety disk (5, fig. 7–16).

Refer to table 7–1 for additional and comparative information concerning the equipment.

Table 7–1.—Characteristics of the equipment

	Type MA-1	Type B-1	Type C-1
Capacity (liquid)	50 gal	150 gal	500 gal.
Expansion space	10 percent	10 percent	10 percent
Weight empty	1,000 lb	890 lb	2,430 lb.
Weight filled with LQOX	1,480 lb	2,330 lb	7,140 lb.
Overall length	106 in	100.5 in	146.5 in.
Overall width	67.5 in	50 in	65.5 in.
Overall height	51 in	54.5 in	70.5 in.
Inner tank material	Aluminum	Aluminum	Aluminum
Jacket material	Aluminum	Aluminum	Aluminum
Working pressure	100 p. s. i	50 p. s. i	50 p. s. i.
Safety valves set at	110 p. s. i	60 p. s. i	60 p. s. i.
Safety disks set at	125 p. s. i	90 p. s. i	90 p. s. i.
Insulated space rupture disk set at.	15 p. s. i	30 p. s. i	30 p. s. i.
Fill-drain coupling	Standard 1-inch National Pipe Threads. (NPT) on all types.		

Operation

Table 7–2 lists the valve positions for LQOX tank use and service.

FILLING THE TANK.—Do not disturb vacuum valve A (yellow). Warm or empty tanks do not indicate a vacuum less than 1,000 microns on the vacuum gage. A thoroughly cooled or filled tank will indicate a vacuum below 250 microns.

Before filling the tank, close the capacity gage bypass valve B, and observe the capacity gage indication. Then open the valve and leave it open.

Set the valves on the receiver (tank to be filled) as listed under FILLING in table 7–2.

Check pressure relief valves 1 and 6 for free operation by pulling handle several times.

With the transfer hose connected to the source and the dust plug removed from the coupling, let a small quantity of LQOX flow from the source (full unit) into the hose. This will expand and clean the hose. Remove the dust cap and couple the transfer hose to the receiver.

When filling converters in aircraft, care must be taken to insure complete cooling of the converter. Failure to cool the converter properly will result in only partial filling and rapid boil off of the LQOX. While spurting liquid indicates a full tank, it does not indicate a properly cooled converter and spurting could continue until enough liquid is exhausted to allow room for rapid boil off.

Slowly open the fill-drain valve on the source which has pressure for transferring the liquid. Keep the fill-drain valve (on the source only) partially open until the transfer hose and receiver are cooled. This takes a minute or so and is indicated by a slowing down of gas escaping from the vent line. Next, open the fill-drain valve on the source and leave open until LQOX spurts from the vent line. Spurting liquid indicates a filled tank.

Close the fill-drain valve on the source. Then close the fill-drain valve on the receiver, and relieve the pressure in the

Table 7-2.—Valve identification and functions

Valve identification		Valve name	Functions				
Letter	Color		Filling	Pressure buildup	Transfer	Vacuum pumping	Liquid storage
A	Yellow	Vacuum	Closed	Closed	Closed	Open	Closed.
B	Black	Capacity gage	Open	Open	Open	Open	Open.
C	Blue	Fill-drain	Open	Closed	Open	Closed	Closed.
D	White	Pressure buildup	Closed	Open	Closed	Closed	Closed.
E	Red	Vent	Open	Closed	Closed	Open	Open.

transfer hose by pulling knob 6 (hose pressure relief valve) until pressure is relieved.

Warning: Some liquid may remain in the transfer hose even after the pressure has been released. Use caution when disconnecting the hose; keep it pointed away from personnel.

After an interval of ten minutes, the capacity gage bypass valve can be closed to indicate the liquid in the tank. This gage does not operate during a transfer. Use the gage only with the liquid "at rest."

TRANSFERRING LQOX FROM THE TANK. Gravity or pressure can be used to remove LQOX from the tank; however, pressure is preferred for economy and speed. ***Caution:*** Check pressure relief valves 1 and 6 for free operation before the tank is used.

Refer to the valve positions in table 7–2 under PRESSURE BUILDUP. Open the pressure buildup valve D slowly and observe the tank pressure on the gage. Close valve D when the desired pressure is reached. After reaching the desired pressure, the tank will be ready to transfer liquid. Do not pressurize over 100 p. s. i. For most transfers, 85 p. s. i. is sufficient. Prepare receiver tank in manner prescribed by the manufacturer.

Attach transfer hose to the coupling and purge before connecting to receiver. With open vent and fill-drain valve on the receiver, open the fill-drain valve and transfer liquid. When the receiver is filled, close the fill-drain valve on the source tank first. Then close the fill-drain valve on the receiver. Release hose pressure before uncoupling, pulling knob 6 until pressure is relieved.

Caution: After transferring liquid, open vent valve E and release all pressure. Place the tank valves in the storage position. (See table 7–2.) A closed vent valve on a storage tank will raise the temperature and pressure of the liquid and pop open pressure relief valve 1 or rupture the safety disk (4, fig. 7–16).

With the type 4 tank pressurized and in position to service the aircraft, remove the hose from its trough. Remove the filler valve dust cap. Place the filler valve firmly and squarely against the purging device (2, fig. 7–16). Purge the valve approximately 20 seconds if warm, or 5 seconds if just used. Purging to cool the hose and valve saves time servicing.

OPERATING THE VACUUM GAGE.—A battery operated thermocouple is used to indicate the absolute pressure (vacuum) in the insulated air evacuated space between the tank and the jacket. The pressure in this space is indicated in microns on the gage (1,000 microns equals 1 mm. Hg pressure and 760 mm. Hg equals sea level pressure).

The batteries are used to operate the gage. On some models the batteries are mounted inside the back cover of the gage; while others have a plug-in battery pack.

With batteries connected, and the tube plugged into the socket on the cable from the gage, depress button (4, fig. 7–15) and hold down or turn the switch (4), if the gage is so equipped. Then depress and hold down button (3) and observe the needle swing across the dial. Use adjusting knob (5) to balance the needle at zero. Release button (3), and read the microns of pressure (vacuum) in the insulated space. Release button (4) or turn switch (4) to OFF after each use. This adds to the service life of the element in the tube.

Caution: If the tank is used in below freezing temperature, the batteries must be removed when the gage is not being used. The battery pack can be carried by the operator and be plugged into the gage for a reading at any time.

Vacuum Pumping the Insulated Space

A pump-down is required when the vacuum exceeds 250 microns with liquid in the tank. A vacuum is most easily pumped in the insulated space when the tank is empty and warm. When in daily use, allow one day for warming a tank before pumping. A vacuum pump of suitable capacity must be used for serving the equipment.

See table 7–2 for valve positions. Remove the blank plate (16, fig. 7–15) from the end of the vacuum valve (9) and attach the vacuum pump hose fitting (17) for the hose using a new O-ring seal (18) before tightening in place.

Lightly coat the seal with a specially prepared vacuum wax and tighten to assure metal-to-metal contact.

Insert the male fitting into the vacuum pump hose and tighten with a hose clamp. Cover the exposed end of the hose with the special wax.

Before opening vacuum valve A (9, fig. 7–15), start the pump and evacuate the air in the hose. Remove the safety wire from the valve and slowly open a quarter turn at a time so any sudden rush of air will not pack the insulating material (Santocel) tightly against the filter which is in the insulated space.

Several hours pumping may be required to lower the pressure to a value considerably below 250 microns with liquid in the tank—the lower the reading, the more efficient the tank. Removing the tank from the pump and filling it with liquid oxygen is the only way to determine if the vacuum in the insulated space between the tanks is adequate.

After vacuum pumping, close valve A (9, fig. 7–15) tightly before stopping the pump. Rewire the valve in the closed position, and replace the blank plate over the valve coupling using a new O-ring seal. Tighten until metal-to-metal contact is assured.

Lubrication

WHEN LUBRICATING THE TRAILER, LUBRICATE THE MOVING PARTS THAT DO NOT COME IN CONTACT WITH LQOX. Figure 7–17 illustrates the lubrication points. WIPE ALL EXCESS GREASE FROM THE TRAILER AFTER SERVICING.

Inspection

Table 7–3 outlines the major inspection schedule for the liquid oxygen trailer.

Troubleshooting

Refer to table 7–4 which outlines a pattern for troubleshooting. Many of the remedies recommended for correction of the troubles listed will require reference to the manual concerned to see what adjustments are to be made for particular equipment or how to replace parts and similar information specific to the equipment being serviced.

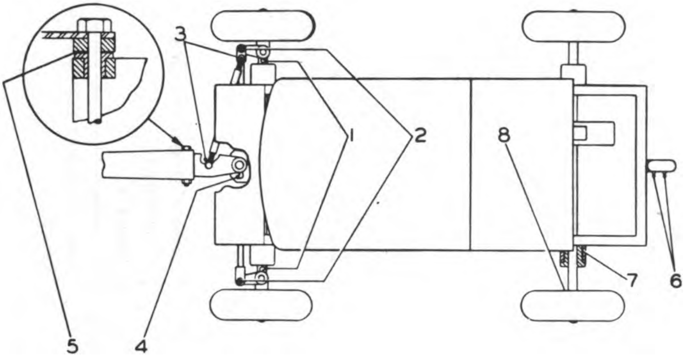


Figure 7–17.—Lubrication chart for LQOX trailer.

1.	Kingpin	Lubricate monthly
2.	Tie rod pin	Lubricate monthly
3.	Drag link end	Lubricate monthly
4.	Steering arm pivot pin	Lubricate monthly
5.	Drawbar bolt	Lubricate monthly
6.	Pintle	Lubricate monthly
7.	Crossheads and spring housings	Lubricate monthly
8.	Wheel bearings	Lubricate annually.

Note: **Grease (Specification MIL–G–10924) and pressure gun are used in areas 1, 2, 3, 4, and 6. Lubricating oil (Specification VV–O–471) is used in area 5. Lubricating graphite (Specification MIL–G–6711) is used in area 7. Pack wheel bearings with the same grease as used in the gun.**

Table 7–3.—Periodic inspection.

Part	Check	Period
Vacuum gage	Vacuum in insulated space	Daily.
Vacuum gage batteries	Corrosion	Weekly.
Vacuum tube hose	Deterioration of rubber	Monthly.
Shock mounts on vacuum gage, capacity gage, thermocouple tube.	Deterioration of rubber	Monthly.
Pressure relief valves	Valve opening at approximately 110 p. s. i., closing at approximately 95 p. s. i.	Monthly.

Table 7-4.—Troubleshooting.

Trouble	Probable cause	Remedy
Restriction of flow while transferring LQOX.	Frozen or foreign material obstructing filters in tank fill-drain line or hose.	Check system to find obstruction and clean, thaw, replace or repair as necessary.
	Ice in hose or filler valve	Do.
Inability to build up pressure to transfer LQOX.	Insufficient amount of LQOX in tank	Refill.
	Lines or pressure buildup coil extremely cold.	Allow to warm up.
	Vent valve not completely closed	Close.
	Plumbing leak	Tighten or repair as necessary.
	Pressure relief valve 1 leaking	Push control knob for positive manual closing. If still leaking, replace.
	Ruptured safety disk in buildup coil safety head.	Replace.
	Obstruction in liquid system lines	Find obstruction, clean or repair as necessary.
	Defective pressure gage	Replace.

Loss, or apparent loss, of vacuum	Punctured rear dome rupture disk	Replace.
	Vacuum valve not tightly closed	Tighten.
	Faulty thermocouple gage or tube	See remedies for faulty gage and tube.
	Leak in vacuum tube hose	Replace.
	Leak in vacuum valve	Replace.
	Leak through vacuum valve diaphragm	Replace diaphragm.
	Defective O-ring in outside vacuum connections.	Replace.
	Foreign material in O-ring grooves	Clean with a soft rag.
	Rough edges on parts contacting rear dome rupture disk have damaged disk.	Recondition or replace as necessary.
Transfer hose safety disk blows when pressure gage shows less than 100 p. s. i.	Pressure relief valve 1 has failed to operate. When fill-drain valve is closed, pressure gage indicates tank pressure only. Pressure in hose and line may have been built up from LQOX in hose.	Check pressure relief valve 1.
Either safety disk fails to blow at above 125 p. s. i.	This is a dangerous condition. Line is obstructed by foreign material or ice. Also the applicable pressure relief valve has failed to operate.	Reduce pressure by opening pressure relief valve manually or by opening vent valve. Clean or thaw line. Check pressure relief valve.

Table 7-4.—Troubleshooting—Continued

Trouble	Probable cause	Remedy
Leaks around safety disk	Rough sealing surfaces around safety disk.	Recondition and replace as necessary.
	Safety disk not positioned in center of passage.	Replace disk being sure it is placed over exact center of line.
Pressure relief valve 6 does not open above 100 p. s. i.	Pull rod or handle binds	Make necessary adjustments.
	Defective valve	Replace valve.
Pressure relief valve 6 opens at less than 100 p. s. i.	Defective valve	Replace.
Pressure relief valve 1 does not open above 110 p. s. i.	Pull rod or handle binds	Make necessary adjustments.
	Valve improperly adjusted	Make necessary adjustments.
	Defective valve	Replace.
Fill-drain, pressure buildup, or vent valve does not allow passage of LQOX or gas.	Defective valve	Replace.

Capacity gage malfunction	Capacity gage valve sticks or will not close tight enough to afford a workable pressure on gage.	Replace valve.
	Valve leaks through pack nut or through seat and disk.	Tighten nut or replace valve as necessary.
	Excessive leaking in hood plumbing	Tighten loose connections.
	Plugged orifice	Replace.
	Foreign material or ice in plumbing	Clean out.
	Defective gage	Replace.
Pressure gage malfunction	Vibration has lodged needle on wrong side of peg.	Remove face and correct needle. Bend slightly if necessary.
	Defective gage	Replace.
	Ice or foreign material in line	Remove line and clean.
Thermocouple vacuum gage malfunction.	Dead batteries	Replace batteries.
	Thermocouple vacuum tube burned out	Replace tube.
	Poor connections at tube end of vacuum gage wire.	Make necessary adjustments.
Restricted LQOX flow through hose	Clogged hose filter disk	Clean or replace filter disk.
	Clogged filter disk in fill-drain line	Clean or replace filter disk.
Filler valve won't disconnect from aircraft after use.	Valve parts frozen so turning action is impossible.	Thaw with warm water or air. Use pipe wrench if necessary. Use care not to crack plastic case.

QUIZ

1. The compressor keeps the pressure in the reservoir cylinder between
    a. 2,000 to 2,300 p. s. i.
    b. 2,000 to 2,150 p. s. i.
    c. 2,000 to 2,200 p. s. i.
    d. 2,000 to 2,500 p. s. i.
2. When cascading, the oxygen flows through
    a. 2 drying towers
    b. 3 drying towers
    c. 1 drying tower
    d. 4 drying towers
3. The water level in the water tank should always be
    a. 9 inches
    b. 8 inches
    c. 6 inches
    d. 7 inches
4. The supply cylinders on the compressor side of the transfer machine should be removed when the pressure drops to
    a. 600 p. s. i.
    b. 300 p. s. i.
    c. 500 p. s. i.
    d. 200 p. s. i.
5. The sliding indicator under the cascade manifolds always points to the cylinder having the
    a. next to lowest pressure
    b. next to highest pressure
    c. highest pressure
    d. lowest pressure
6. The supply cylinders on the cascade side of the transfer machine are removed when the pressure drops to
    a. 600 p. s. i.
    b. 200 p. s. i.
    c. 500 p. s. i.
    d. 700 p. s. i.
7. If an unusual condition arose while transferring with the transfer machine, the first thing to do is to
    a. open all manifold valves
    b. close all manifold valves
    c. stop motor or engine
    d. open water trap valve

8. When the chemical has lost its drying capacity, the indicator in the drying tower turns
   a. pink
   b. red
   c. blue
   d. purple
9. The cylinders used on a servicing trailer unit are manufactured under
   a. ICC3A 1,800 p. s. i.
   b. ICC3E 2,400 p. s. i.
   c. ICC3E 1,800 p. s. i.
   d. ICC3AA 2,400 p. s. i.
10. The safety disk on the low-pressure adapter fitting will rupture at
    a. 477 p. s. i.
    b. 476 p. s. i.
    c. 450 p. s. i.
    d. 462 p. s. i.
11. The safety disk on the high-pressure adapter will rupture at
    a. 1,800 p. s. i.
    b. 2,100 p. s. i.
    c. 2,175 p. s. i.
    d. 2,150 p. s. i.
12. The filling pressure of a high-pressure aircraft cylinder depends on
    a. temperature
    b. size of the cylinders
    c. number of cylinders
    d. humidity
13. The chemical drier in the drying tower should be checked after every
    a. 10 cylinders
    b. 12 cylinders
    c. 8 cylinders
    d. 6 cylinders
14. The line valve may be lubricated with
    a. oil
    b. ammonia free graphite
    c. grease
    d. silica gel
15. The servicing recharging trailer uses a
    a. pressure regulator
    b. diluter-demand regulator
    c. demand regulator
    d. balanced pressure regulator

CHAPTER 8

CYLINDERS AND VALVES

All compressed gas containers are cylindrical in shape for a very good reason. Squared or rectangular-shaped containers do not have the strength that spherical and cylindrical constructions offer. Many space saving and other related problems could be solved if a more adaptable box-shape could be utilized in containing highly compressed gases.

Chapter 1 served to introduce and acquaint the reader with the subject of cylinders. This chapter is more complete and comprehensive. Here in addition, the valves used in conjunction with compressed gas cylinders are discussed. This will lead to a better understanding of the difference between packed and packless type valves. The physical characteristics of CO_2 cylinders and their assemblies used in life raft inflation systems are other subjects of the chapter. Since the Parachute Rigger handles acetylene, a number of brief comparisons are also made for identification and safety purposes.

CYLINDERS

Identification of Cylinders

NAVY MARKINGS.—Navy-owned cylinders for gases in the liquid state with a water-filled capacity in excess of 15 pounds, or for gases in the gaseous state with a volume in excess of 658 cubic inches, are identified by a Navy serial number indented in the neck of the cylinder and followed by the letters USN. Acetylene cylinders used in Halide detector tests contain acetylene dissolved in acetone, and are assigned Navy serial numbers on the volume basis. Cylinders exceeding 2 inches in diameter are required by Interstate

Commerce Commission (I. C. C.) regulations to be indented with serial numbers. Therefore, cylinders exceeding 2 inches in diameter which are not assigned Navy serial numbers require manufacturer's lot numbers, not to exceed 500 cylinders in each lot. ICC8 (Acetylene) cylinders of all sizes require serial numbers with no limit to the number per lot.

Since August 1944, Navy serial numbers have been added to by a designated letter preceding the numbers, which further identifies the cylinders with respect to the specific gas contained therein. The lettering system consists of the arbitrary allocation of the following letters to the gases indicated:

A—Acetylene.
D—Carbon dioxide.
X—Oxygen.

Cylinders without gas-indicating letters, manufactured before 1 August 1944, are approved for naval service. A list of identifying serial numbers of these cylinders may be obtained from the Bureau of Ships.

I. C. C. MARKINGS.—In addition to the marking requirements of the Navy, gas cylinders are manufactured and maintained in accordance with the regulations of the Interstate Commerce Commission. To assist in carrying out the I. C. C. regulations, each cylinder which is subject to the regulations is indented or stenciled with both Interstate Commerce Commission and Navy identifying markings. Navy-owned compressed gas cylinders are identified with figures and letters as shown in table 8–1.

Explanatory notes for table 8–1:

1. I. C. C.—Interstate Commerce Commission.
2. ICC followed by 3A, 4B, 8, etc., indicates governing I. C. C. specification.
3. ICC3A or 4B, etc. followed by 1800, 2015, etc., indicates maximum charging pressure at normal temperature (68°–70° F.)
4. SPUN—If present, indicates method of manufacturing cylinders. Other cylinders are usually deep drawn and die formed.

Table 8-1.—Cylinder markings

Markings on one side of cylinder	Examples
I. C. C. mark and SPUN when spun cylinders are so manufactured.	Oxygen cylinder—ICC3A—1800—SPUN. Acetylene cylinder—ICC8.
Manufacturer's symbol—Navy serial number—letter and NONSHAT if cylinder is the nonshatterable type.	Oxygen cylinder—MFG—$\underset{N}{\overset{U}{S}}$X50789$\underset{N}{\overset{U}{S}}$—NONSHAT. Acetylene cylinder—MFG—$\underset{N}{\overset{U}{S}}$—A45678$\underset{N}{\overset{U}{S}}$.
Third party inspection mark and Navy inspector's stamp.	(INSP) Symbol. (NAVY) (INSP) Symbol.

Markings on other side of cylinder	Examples
Navy specification number and date (month and year).	Oxygen, 51C31—10/47, D, Acetylene, 51C30—10/47.
Tare weight of cylinder in pounds (when required).	115.6 pounds or as appropriate.
Original and subsequent test dates (months and year).	10/47 or as appropriate.

5. MFG—to indicate where manufacturer's symbol should be located.
6. MFG followed by $\overset{U}{\underset{N}{S}}$A, $\overset{U}{\underset{N}{S}}$X, $\overset{U}{\underset{N}{S}}$S, etc., and subsequent numbers (Navy serial numbers).
7. NONSHAT indicates cylinder is manufactured in accordance with Navy specifications for nonshatterable cylinders (under ballistic attack). Ships should stock only nonshatterable cylinders.
8. Tare weight indicates weight of cylinder and valve—does not usually include cap.
9. Exact placement of figures and letters may vary—depending on size and type of cylinder.

Color code for cylinders.—Gases used by the three services, Navy, Army, and Air Force, carry certain standard identifying features in addition to the markings described.

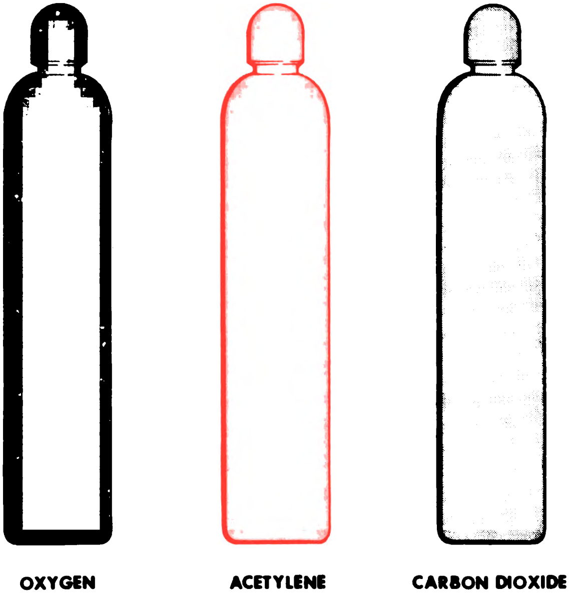


Figure 8–1.—Identifying color patterns for gas cylinders.

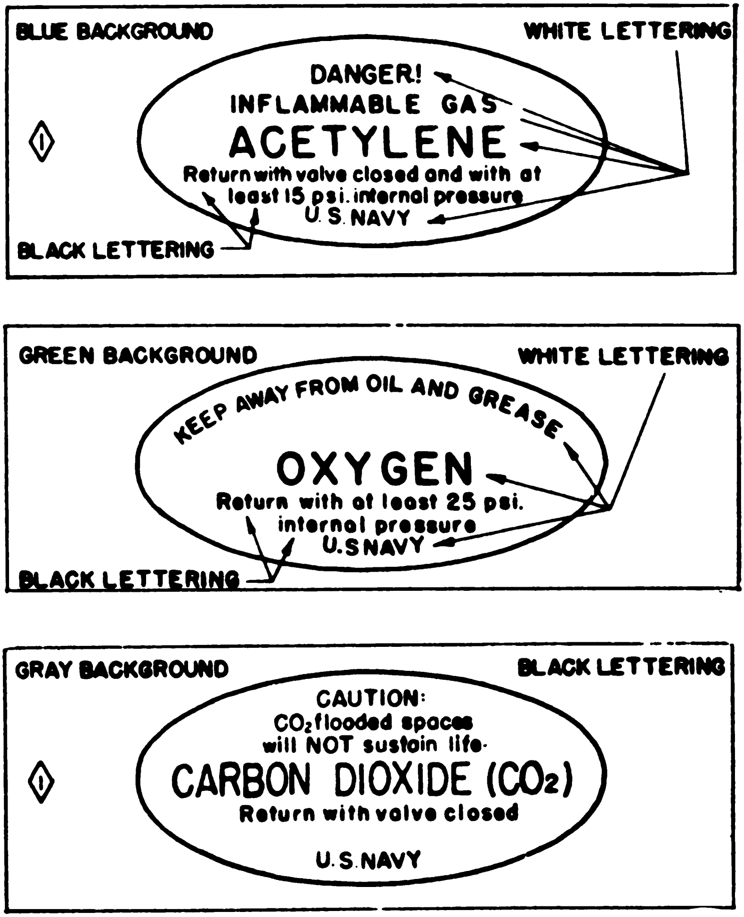


Figure 8–2.—Standard decalcomanias for Navy gas cylinders.

Great injury and damage can be, and has been, caused by mistaking one gas cylinder for another. A national program has been established to make it almost impossible to confuse cylinders. The identifying features used by the Armed Forces in this program consist of a color code for painting the cylinders, stenciling the name of the gas along two sides of the cylinder, and affixing two decalcomanias to the shoulder of each cylinder.

Figure 8–1 shows how cylinders are identified by the overall painted color code and by the stenciled name of the gas. Figure 8–2 shows the related decalcomanias which are placed opposite each other.

Rules for Cleaning and Painting Cylinders

Cylinders shall never be painted colors other than those indicated in the color code for compressed gas cylinders and pipelines, Military Standard (MIL–STD–101). When camouflage is necessary, canvas or other materials painted with camouflage colors may be placed over the cylinders.

Cylinders should never be painted on their interior surfaces.

Valves must be kept free from paint. Navy and Interstate Commerce Commission serial numbers and test markings must not be obliterated.

Before painting cylinders, all loose paint, scale, rust, and dirt must be removed. When spark-producing tools such as wire brushes or metallic scrapers are used, the cleaning operation should be done in the open or in a well-ventilated compartment with fire fighting equipment available.

Before any cleaning operation, the valves, safety devices, and fusible plugs of cylinders containing flammable gases should be tested with soapy water for leaks.

Leaking cylinders should not be cleaned, but should be returned to an authorized repair activity.

Testing and Repairing Cylinders

FIVE-YEAR RETESTS.—I. C. C. regulations require quinquennial (5-year) retesting of practically all cylinders with the exception of acetylene cylinders. Cylinders for which prescribed retests have become due must not be charged and shipped until such retests have been properly made. However, cylinders which have been charged prior to the expiration of their retest period may be shipped and used until empty before being retested.

The 5-year hydrostatic tests are performed by naval activities and civilian establishments under regulations of the I. C. C.; and specially approved testing equipment is required. Since ships are not authorized to conduct such tests, empty cylinders with expired test periods should be returned to the nearest naval supply depot or cylinder testing activity marked FOR RETEST.

REPAIRS.—Cylinders are repaired only by ships which are specifically authorized to perform such work. To assure that all cylinders aboard ship are in satisfactory and serviceable condition, periodic inspections should be made and defective cylinders should be relieved of pressure and turned in to the nearest naval supply depot in exchange for other cylinders. The following marks or defects require the cylinder to be turned in for repair:

1. Severely dented, gouged, or corroded.
2. Evidence of fire damage (carbon deposits on valves or safety plugs of cylinders containing acetylene or other flammable gases).
3. Bulges (deformation of cylinders from internal pressure).
4. Damaged, split, or leaking seams (low-pressure cylinders containing flammable gases such as acetylene).

Handling of Cylinders

GENERAL RULES.—Study the rules which follow. Although many of them do not concern CO_2 directly, their relationship is informative and interesting. Remembering that the Parachute Rigger's duties involve the use of welding equipment (as in brazing high-pressure fittings), one must not disregard references to technical grade oxygen and acetylene. Gas in any liquid form or in a state of further compression, such as solid CO_2 or dry ice, will "burn" the skin if touched. The general handling rules are as follows:

1. Cylinders that contain flammable and/or explosive gases must be handled with particular care. Every effort should be made to avoid their being dropped or allowed to strike forcefully against each other or any other object. Every precaution must be taken to prevent bumping or striking the discharge valves during handling operations.

2. Both the cylinder valve outlet cap and the cylinder

valve protecting cap must be in place when cylinders are being handled. Unless ready service cylinders are secured in a special portable rack, regulators shall be removed and caps replaced before the cylinders are moved to a new location.

3. When loading or transferring cylinders, especially when using a crane or derrick, the cylinders must be secured in a cradle, suitable platform, rack, or special container such as a sandbag. ELECTROMAGNETS MUST NEVER BE USED. A cylinder moved by hand should be tilted slightly and rolled on its bottom edge, without dragging or sliding. Hooks or lines through the valve protection cap shall not be used for hoisting cylinders. Cylinders frozen to the deck, or otherwise fixed, must not be pried loose with crowbars or similar tools.

4. When cylinders are transported on a hand truck, they must be held securely in position. The truck should be fastened to a bulkhead or stanchion as soon as the destination is reached. All trucks should conform to the following design characteristics:

   a. Frame should be sufficiently rigid to permit handling with tackle.
   b. Grips or handles should extend in a vertical line with the aft side of the wheels to facilitate fastening to a bulkhead.
   c. Platform should be fitted with sides to prevent cylinders from sliding off.
   d. Metal strap clamps shall be provided in lieu of chains for retaining the tops of the cylinders in place.

STORAGE OF COMPRESSED GASES.—In general, weather-deck stowage will be provided for flammable and explosive gases. However, in specific cases below-deck stowage is approved depending on the particular type, mission, and arrangement of the vessel. In such cases, these approved locations are shown on the plans of the vessel.

Compressed gases aboard all vessels, except cargo vessels, shall be stowed only in compartments designated by the Bureau of Ships as shown in applicable plans for the vessel. The following precautions must be observed:

1. Necessary steps shall be taken to prevent the maximum temperature of the stowage compartment from exceeding 130° F.

2. When provisions are made for mechanical ventilation, this ventilation shall be operated in accordance with the damage control classifications assigned. The classification for closure of this system is "Z" or "W."

3. In compartments designated for the stowage of flammable or explosive gases, the installation of portable electric wiring and equipment is not permitted.

4. Flammable materials, especially grease and oil, must be kept out of the stowage space, and the space be kept clean.

5. Each individual cylinder shall be securely fastened in the vertical position (valve end up) by means of metal collars. On cargo ships fitted especially for cylinder transport, other arrangements are approved.

6. Oxygen and chlorine shall be stowed in compartments separate from flammable gases. Inert or nonflammable gases may be stowed in any compartment designated for compressed gas stowage.

7. Compartments containing compressed gases shall be ventilated for 15 minutes prior to entry in event ventilation has been closed down; and a suitable sign to this effect shall be prominently posted on the outside of the access door.

When compressed gas is stowed on the weather deck, the following precautions must be observed:

1. Oxygen and chlorine cylinders stowed on the weather deck shall not be in close proximity to fuel-gas cylinders.

2. Cylinders containing compressed gases should be stowed so that they will be protected. During winter, cylinder valves must be protected against accumulation of snow and ice. Warm (not hot) water shall be used to thaw ice accumulations in cylinder valve caps and outlets. During summer, cylinders shall be screened from direct rays of the sun. Every effort should be taken to prevent stowage for extended periods of time.

3. The stowage area shall be as remote as practical from navigating, fire control, and gun stations.

4. Other flammable materials, especially grease and oil, shall be kept out of the stowage area.

5. Each individual cylinder shall be securely fastened in the vertical position (valve end up) by such means as metal collars.

Fire extinguishers employing gases, fire extinguishing cylinders permanently connected to fixed fire extinguishing systems, and chemical canisters for oxygen breathing apparatus may be stowed in the vicinity in which they are used.

DISPOSITION OF EMPTY CYLINDERS.—Empty cylinders should be delivered to the nearest naval supply depot with valves closed and under some positive pressure, except where the design of the valve does not permit closing, as in the case with fire extinguishers. This pressure is necessary to prevent condensation of atmospheric moisture on the internal walls, and, in the case of acetylene cylinders, to prevent loss of the solvent (acetone) and/or entry of air, should the cylinders cool considerably below the temperature at which they were discharged.

Cylinders used for aviator's breathing oxygen, dry nitrogen, argon, or dry air, which are found to have open valves and/or a positive internal pressure of less than 25 p. s. i., should be tagged with this explanation because they must be dried before refilling. This is a 9.3 p. s. i. safety margin of positive pressure in excess of atmospheric pressure, and thus is the ideal empty cylinder value.

LOANS AND SURVEYS OF CYLINDERS.—Navy-owned cylinders shall not be loaned to private parties or other Government activities without the specific approval of the General Stores Supply Office (GSSO) except in cases where an emergency is deemed to exist and such action is approved by the commanding officer. In both cases, the marking of the cylinders so loaned (Navy serial numbers, Interstate Commerce Commission markings, capacity, and service of cylinder such as oxygen, acetylene, etc.) shall be recorded and reported to the GSSO along with the details of the transaction.

Survey reports on cylinders from ship's stores which were jettisoned at sea shall contain all data indented on the shoulders of the cylinders. Such survey reports should be forwarded to the Bureau of Supplies and Accounts.

CO_2 Supply Cylinder

Figure 8–3 illustrates the standard CO_2 cylinder which is used universally to refill a myriad of other small types of cylinders.

Characteristics of the CO_2 supply cylinder are as follows:

Capacity at N. P. T.*	50 pounds
Working pressure	1,800–2,015 p. s. i.
ICC specification	ICC3A
Dimensions (approx.)	Diameter, 8½ inches Length, 51 inches
Weight (empty) (approx.)	110–115 pounds
Outlet connection	¾ inch
N. D. specifications	51C26

*Normal temperature and pressure 68°–70° F. and atmospheric pressure.

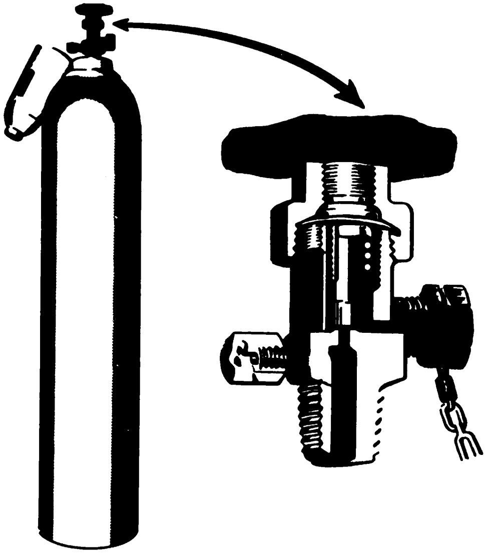


Figure 8–3.—CO_2 supply cylinder.

VALVES

Navy Standard Valves

Navy standard valves are of two basic designs: Packed valves and diaphragm type packless valves. CO_2 and oxygen handwheel type valves employ the second type design.

Packed valves require a packing material around the valve stem to prevent leakage, whereas valves (used mainly in high-pressure cylinders) are sealed against leakage around the valve stem by flexible metallic diaphragms securely clamped to the valve bonnets.

The basic packless design may be classified into two types: (1) the NON-BACK-SEATING type, which are designed so that the metallic sealing diaphragms may NOT be replaced UNDER PRESSURE, and (2) the BACK-SEATING type, in which the metallic diaphragms may be replaced without undue hazard or loss of contained gases, provided the outlet cap is in place and secure. Replacement of diaphragms in packless valves should be done only by activities carrying spare diaphragms specifically designed for the valves in need of reconditioning. Diaphragms are fabricated from materials selected for service at high pressure while dynamically loaded. In addition, they are often of a design suitable only for use with valves fabricated by a given manufacturer and for a specific gas.

One of the features of the Navy gas valve program (and of civilian agencies) is to provide noninterchangeable valve outlets and connections for different gases to prevent using the wrong gas at any time.

Identification of Valves

Valves manufactured in accordance with the latest provisions of Navy Department Specifications have the name of the gas or service for which they are designed indented on them. This will appear on at least one of the flats on the side of each valve. A VALVE MUST BE USED ONLY FOR THE GASES OR FLUIDS INDICATED. Valves manufactured in accordance with earlier and now obsolete specifications

Table 8-2.—Navy cylinder valve outlets—Military Standard 1950

Service	Inlet				Outlet			
	Thread diameter (inch)	Direction thread	Threads per inch	Type threads	Outside thread diameter (inch)	Direction thread	Threads per inch	Type threads
Acetylene	1	Right-hand	11½	Male	0. 830	Right-hand	14	Male.
Carbon dioxide	¾	do	14	do	. 825	do	14	Do.
Oxygen	¾	do	14	do	. 903	do	14	Do.

NOTES:

1. Valves for service other than listed have outlet connections in accordance with commercial specifications and as approved by the Bureau of Ships. For further information see Table VI, Chapter 23, *BuShips Manual.*
2. For carbon dioxide fire extinguisher valve see Chapter 93, *BuShips Manual.*

Table 8-3.—Federal and commercial standard cylinder valve outlets, 1950

Service	Outlet thread				Mating thread			
	Thread diameter (inches)	Direction threads	Threads per inch	Type threads	Thread diameter (inches)	Direction threads	Threads per inch	Type Threads
Acetylene	0. 885	Left-hand	14	Female	0. 880	Left-hand	14	Male.
(Alternate)	. 825	Right-hand	14	Male	. 830	Right-hand	14	Female.
Carbon dioxide	. 825	do	14	do	. 830	do	14	Do.
Oxygen	. 903	do	14	do	. 908		14	Do.

Notes:

1. This standard conforms to the valve outlets which will be specified in a forthcoming specification for compressed gas cylinder valves in naval service. Announcement will be made of the effective date upon which this standard supplants the outlets specified in Table V, Chapter 23, *BuShips Manual*.
2. Valve outlets for service not covered by Table V, Chapter 23, *BuShips Manual*, should be in accordance with this standard.
3. Outlet connection indicated as alternates will not be approved for naval service after announcement of effective date.

Table 8–4.—Valve outlet thread designations according to military standard MIL–V–2

Gas	Type of valve	Outlet thread designation	Type
Acetylene	03–511–1	0. 885″–14NGO–LH	Int.
	03–511–2	0. 885″–14NGO–LH	Int.
	03–201–3	0. 625″–20NGO–RH	Ext.
	03–201–4	0. 625″–20NGO–RH	Ext.
Carbon dioxide	02–321–1	0. 825″–14NGO–RH	Ext.
	02–321–2	0. 825″–14NGO–RH	Ext.
Oxygen	01–541–1	0. 903″–14NGO–RH	Ext.
	01–541–2	do	Do.
	01–541–3	do	Do.
	01–541–4	do	Do.

LH—Left-hand threads.
NGO—National gas outlet threads.
RH—Right-hand threads.

Size symbol designation of threads are based on the maximum major diameter for external threads and on the minimum major diameter for internal threads. All inlet connection threads are right hand none of which are shown in the table for the gases listed.

were not identified by the name of the gas. The thread sizes and distinctive features of current Navy CO_2 valves used on standard cylinders are listed in tables 8–2, 8–3, and 8–4. Information on large acetylene cylinder valves and the standard oxygen valve is also included.

The Navy, in cooperation with other Government agencies and with industrial technical societies, has developed standard threads for all valves used with compressed-gas cylinders. Many of the standard Navy threaded connections of valves are retained in the developed standard. To date, only the valve outlet connections have been standardized in accordance with the data shown in tables 8–2, 8–3, and 8–4. The effective date for adoption of the valve outlet standard shown will be announced by directives to all activities. This means that after July 1950 all valves used by the Armed Forces should conform to the specifications shown in table 8–3.

Safety Devices for Valves

Navy Department specifications and I. C. C. regulations require that valves designed for certain services be fitted with safety devices as a safeguard against the building up of hazardous pressures within cylinders from exposure to heat, from overcharging, or similar causes. In general, these safety devices may be divided into four categories based on functional design; however, only three concern the kinds of gas encountered by the Parachute Rigger. These three safety devices are:

1. FUSIBLE PLUGS.—A fusible plug may be described as a threaded hex-head plug, the center of which is filled with fusible metal. When the cylinder is subjected to high temperatures, the fusible metal melts and permits gas to escape. This type device is used with acetylene, and similar gases.

2. UNBACKED SAFETY CAP WITH RUPTURE DISK.—Unbacked safety caps with rupture disks consist essentially of a safety cap covering a safety port in the valves. The cap retains a frangible disk firmly over the safety port. Under excessive pressures ranging from 2,700 to 3,000 p. s. i., the safety disk ruptures and allows the gas in the cylinder

to vent to the atmosphere. This type safety device is used in carbon dioxide equipment.

3. Backed safety cap with rupture disk.—Backed safety caps with rupture disks are essentially the same as the kind described above, except that the frangible disk is supported by fusible metal contained in the safety cap, thus blocking off escape ports. In practice where the cylinder, valve, and fusible metal are heated above the melting temperature the frangible disk ruptures when the internal pressure approaches 2,700 to 3,000 p. s. i. This type device is used on oxygen valves.

Leaking Valves

Generally, cylinders with leaking or defective valves (stripped threads or bent stems) shall be turned in to the nearest naval supply depot for overhaul. Leakage may also be caused by the presence of dirt or foreign particles in the valve or on the valve seat. This type leakage may sometimes be corrected by partially opening and then closing the valve to blow out the foreign material. If the leakage continues, the cylinders should be removed to a safe place in the open if possible, and emptied by opening the valve. The cylinders should then be tagged and turned in for overhaul and recharging.

CO_2 CYLINDER SYPHON TUBES

Supply cylinders not equipped with syphon tubes must be turned upside down during the transfer process. Inverting the cylinder permits the liquid to flow out of the valve in the most efficient manner. Supply cylinders equipped with the syphon tube, which is a straight pipe extending down through its center to the bottom, can be emptied (for all practical purposes) while standing in the vertical position. Inside the cylinder, pressure on the top of the liquid forces it up and out the open valve.

Life raft inflation, vapor dilution, and hydraulic actuator cylinders, among others too numerous to mention, are all equipped with a syphon or draining tube of some

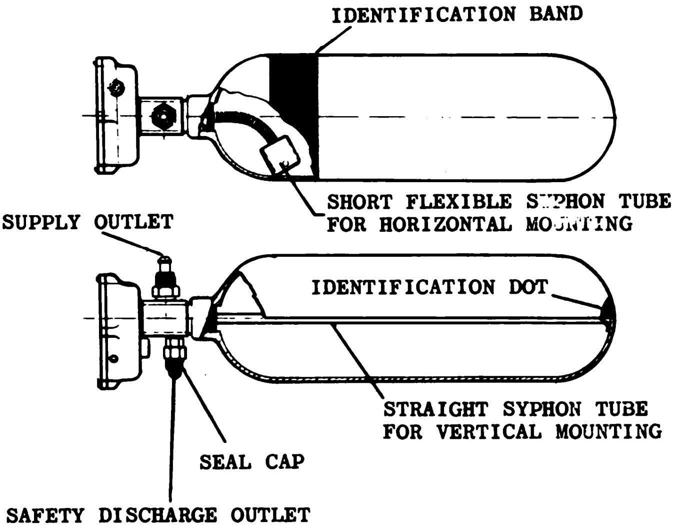


Figure 8–4.—Flexible and straight syphon tubes.

kind. The type of syphon used depends on the use of the cylinder and how it is to be mounted. A syphon tube may be the straight type, flexible long or flexible short. (See fig. 8–4) The syphon tube marking is shown on the cylinder by the use of black bands or spots painted on its exterior. A stenciled notation concerning the type and use is also shown.

SHATTERPROOF CYLINDERS

The cylinders used in conjunction with emergency equipment, designed for use in aircraft, must be shatterproof. Shatterproof cylinders are identified by a 2-inch white stripe painted on their sides. You will recall, the shatterproofing is accomplished by either a heat treating process or by a wire wrapping which encompasses the body of the cylinder throughout most of its length. Nonshatterproof CO_2 cylinders, such as some older type supply cylinders, do not carry the distinguishing white stripe. Only shatterproof CO_2 cylinders should be used in aircraft systems and related equipment.

LIFE RAFT INFLATION EQUIPMENT

To attempt showing and describing all the numerous kinds of inflation devices manufactured for the Navy would be impractical. By arbitrarily choosing one manufacturer, we will present a good cross section of the types of devices used to inflate rubber life rafts. (See figs. 8–5 through 8–11.) The cylinders, discharge heads, and valve assemblies shown are manufactured by the Walter Kidde Company in Belleville, New Jersey.

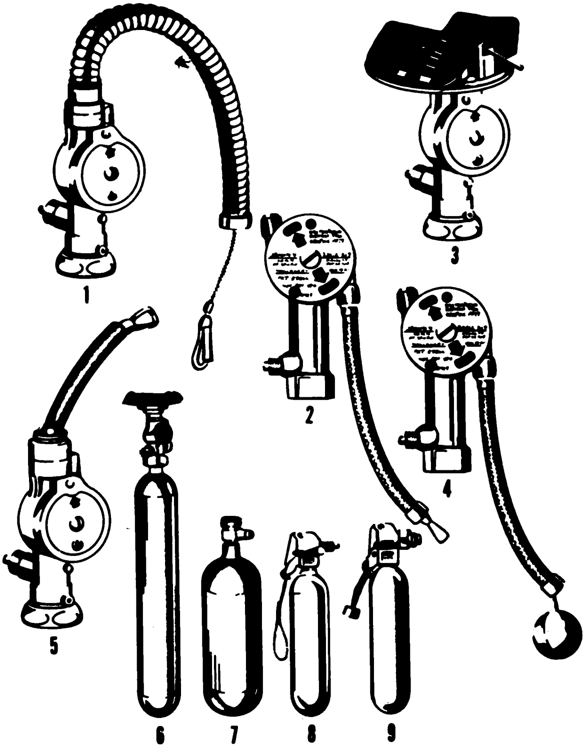


Figure 8–5.—Raft inflation equipment.

1–5. Discharge head assemblies
6, 8, 9. Cylinder and valve assemblies
7. Cylinder and disk body assembly

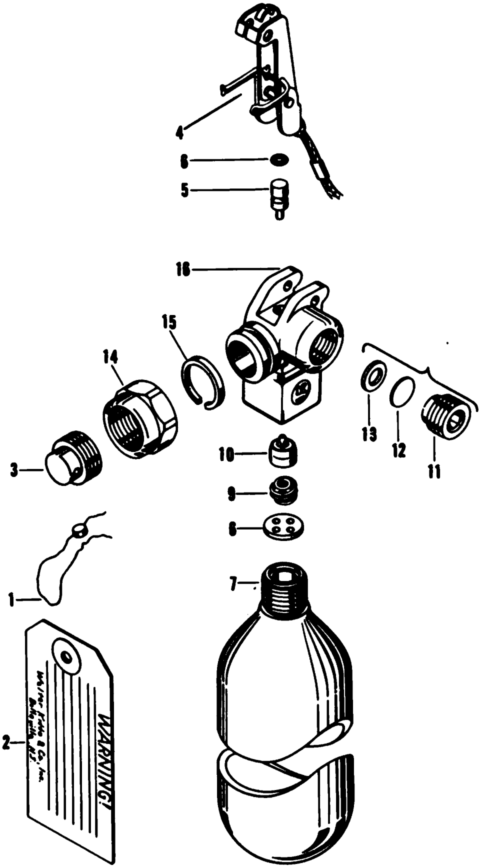


Figure 8–6.—Cylinder and valve assemblies used on the pararaft.

1. Wire seal.
2. Warning tag.
3. Recoil plug. *Note:* In some instances, under approval, this fitting is eliminated to conserve expense and weight.
4. Handle and pull cord assembly.
5. Plunger.
6. O-ring hydraulic packing, ⅛ ID×¼ OD×1/16 inch thick.
7. Cylinder, 20.4 cu. in. capacity.
8. Bottle washer.
9. Check spring.
10. Check.
11. Safety disk plug.
12. Safety disk.
13. Safety disk washer.
14. Coupling nut.
15. Brass wire.
16. Valve body.

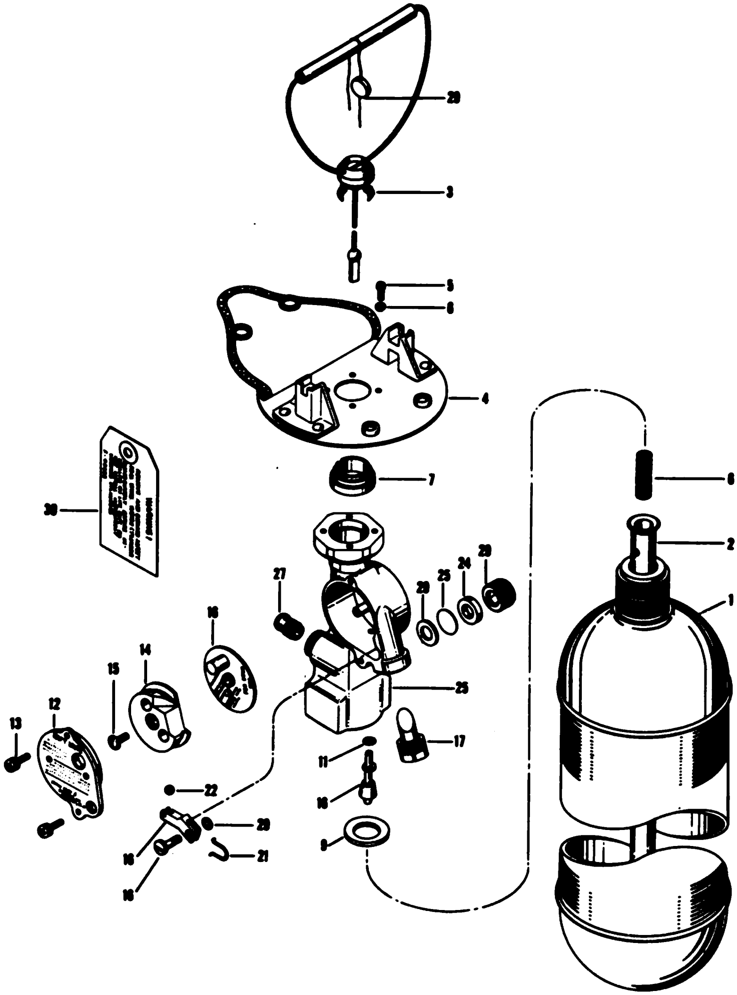


Figure 8–7.—Cylinder and valve assemblies used on multiplace life rafts. (Note that valve does not employ a cutter.)

Nomenclature for figure 8–7

1. Cylinder, Nonshatterable, 96 cu. in., 147 cu. in., or 205 cu. in.
2. Syphon tube.
3. Valve assembly hand pull.
4. Guard flap and plate.
5. Screw.
6. Washer.
7. Retainer.
8. Spring.
9. Gasket.
10. Stem.
11. O-ring packing.
12. Cover.
13. Screw.
14. Sheave.
15. Screw.
16. Camplate.
17. Plug.
18. Lever.
19. Stud.
20. Washer.
21. Lever spring.
22. Roller.
23. Retainer.
24. Plug.
25. Safety disk.
26. Safety disk washer.
27. Recoil adapter.
28. Valve body.
29. Wire seal.
30. Tag.

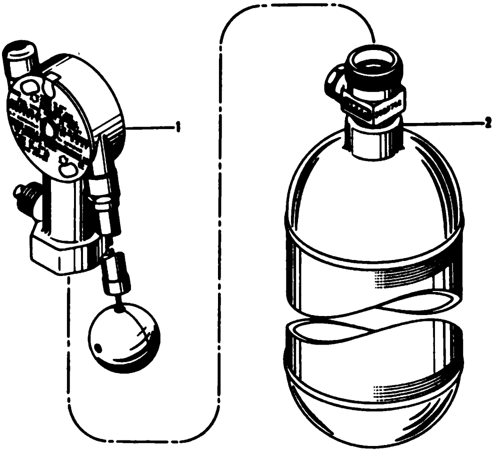


Figure 8–8.—Cylinder, disk body, and discharge head assemblies used on multiplace life rafts.

1. Discharge head assembly (seat type). (See fig. 8–9.)
2. Cylinder and disk body assemblies. (See fig. 8–10.)

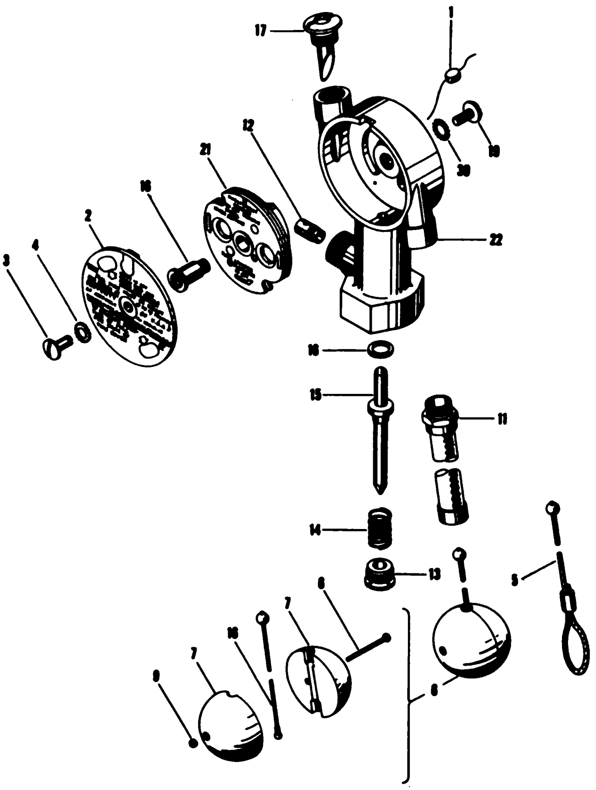


Figure 8–9. Discharge head assemblies employing cutter-type action.

1. Wire seal, copper and lead.
2. Cover.
3. Screw.
4. Washer.
5. Cable.
6. Ball and cable assembly.
7. Half-ball.
8. Screw.
9. Brass hex nut.
10. Cable.
11. Cable housing.
12. Nonrecoil outlet.
13. Retainer.
14. Spring.
15. Cutter.
16. Washer.
17. Swivel plug.
18. Stud.
19. Screw.
20. External teeth type lockwasher.
21. Sheave and cam.
22. Discharge head body.

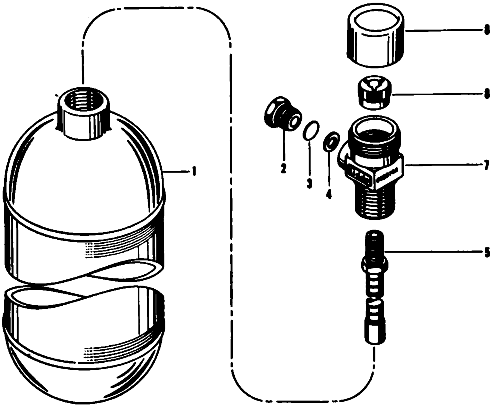


Figure 8–10.—Cylinder and disk body assemblies adaptable to bushing disks and cutter-type discharge heads.

1. **Cylinder (Number 1 in the figure represents five sizes, each one capable of containing a specified CO_2 charge as follows: 1.80 lbs., 2.05 lbs., 3.25 lbs., 4.70 lbs., and 9.40 lbs. When the 3.25-lb. size cylinder is winterized with nitrogen, it contains a lesser charge—2.98 lbs., and when the 4.70-lb. size cylinder is winterized it contains 4.32 lbs.)**
2. **Safety disk retainer.**
3. **Safety disk (two different capacities).**
4. **Safety disk washer.**
5. **Syphon tube (four different sizes).**
6. **Disk bushing, red or black, depending on capacity.**
7. **Body (three different sizes).**
8. **Shipping cap.**

OPERATING PRINCIPLES OF THE CUTTER-TYPE DISCHARGE HEAD AND CYLINDER.—Pulling a cable releases the cutter which is under spring action. The cutter pierces a sealing disk in the neck of the cylinder. CO_2 discharges through the ruptured disk, bypassing the cutter and passes on through the outlet into the raft inflation compartment. A new disk must be installed in the cylinder adapter after each use. This necessity constitutes the temporary removal of the head or bonnet during the recharging process.

OPERATING PRINCIPLES OF THE SEAT-TYPE DISCHARGE HEAD AND CYLINDER.—Pulling a cable turns a cam or sheave which actuates a stem and opens a seat, thereby admitting CO_2 into the raft compartment through the outlet of the

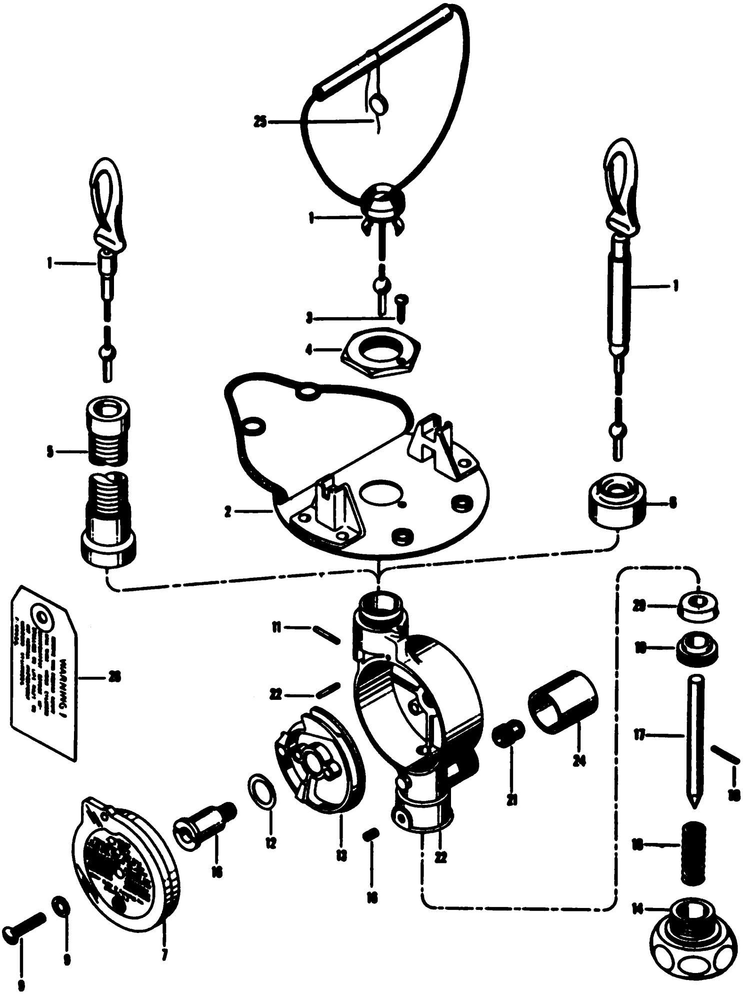


Figure 8–11.—Discharge head assemblies employing cutter-type action with hand and remote pull cables.

Nomenclature for figure 8–11

1. Pull cables.
2. Guard flap and plate.
3. Screw.
4. Collar.
5. Cable housing.
6. Cable outlet cap.
7. Nameplate cover.
8. Screw.
9. Washer.
10. Stud.
11. Pin.
12. Shim.
13. Cam pulley.
14. Bottom cap.
15. Screw.
16. Spring.
17. Disk cutter.
18. Pin.
19. Packing retainer.
20. U-cup hydraulic packing.
21. Recoil adapter.
22. Pin.
23. Body.
24. Protection cap.
25. Wire seal.
26. Tag.

Note: Pull cables (1) are adaptable to remote control systems. The use of one or the other is dependent on its adaptability to a specific aircraft in relation to its life raft inflation system.

discharge head. It is not necessary to remove the discharge head for recharging after each use. A disk is not employed.

RECOIL FITTING.—A recoil fitting installed in the outlet diffuses the expanding CO_2 charge. In the event of accidental discharge, as in a case where the cylinder is held loosely, the recoil fitting prevents a concentrated stream of CO_2 from propelling the cylinder at a high velocity. The recoil fitting thus prevents a static cylinder from becoming a missile of destruction.

COMPRESSED GAS CYLINDER DIMENSIONS

A study of the Standard AN Drawings will help clarify the physical characteristics of the numerous smaller type cylinders (smaller than the supply cylinder) used by the Armed Forces. (See figs. 8–12 and 8–13 and tables 8–6 and 8–7.) Knowing the internal volume of a cylinder is not always enough when one is faced with the problem of deciding which valve or disk body will fit into the neck of a particular cylinder. The drawings presented eliminate trial and error from the application of the knowledge. In other words, by reference, measurement, and comparison, you will know that you are right when matching a particular cylinder for a particular job. Notice the formula presented in table 8–6 for computing the MAXIMUM CO_2 capacity of a cylinder in pounds. Of course, memorizing the formula may be as

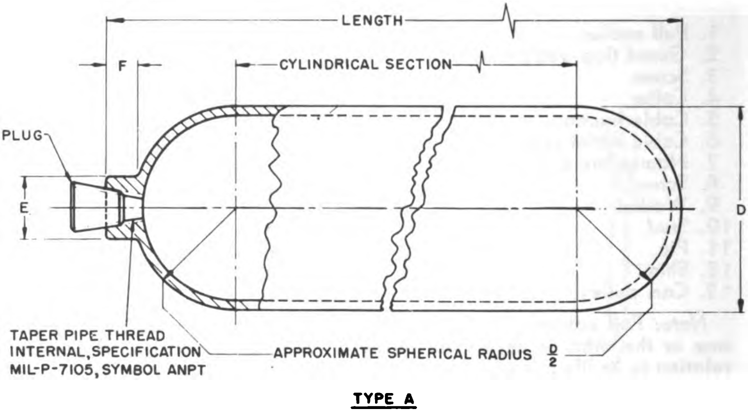

LENGTH
F
CYLINDRICAL SECTION
PLUG
E
D
TAPER PIPE THREAD INTERNAL, SPECIFICATION MIL-P-7105, SYMBOL ANPT
APPROXIMATE SPHERICAL RADIUS $\frac{D}{2}$
TYPE A

Figure 8–12.—Nonshatterable compressed gas cylinder, type A.

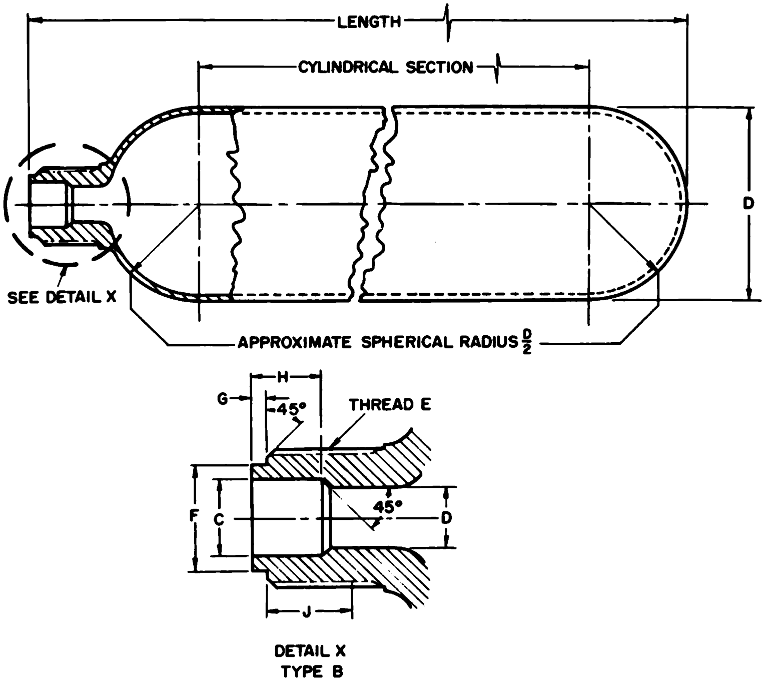


Figure 8–13.—Nonshatterable compressed gas cylinder, type B.

Table 8–5.—Rated CO_2 capacity for shatterproof cylinders

CO_2 rated capacity (pounds)	Internal volume (cubic inch)
1.40	57.0
2.36	96.0
3.61	147.0
5.00	205.0
7.25	295.0
12.60	514.0
15.88	646.0
21.00	853.0

easy as putting to memory the comparatively few rated-capacity figures involved in the treatment of the subject.

Table 8–5 illustrates the most popularly used CO_2 cylinders and their rated CO_2 capacities.

POWER ACTUATING CYLINDER

In the event of hydraulic system failure, the power actuating cylinder, as its name implies, is used to actuate or "blow down" the landing gear of some aircraft. CO_2 cylinders used for this work are painted with green and black bands around the body. Many of the corresponding valve assemblies are designed for the specific job at hand although the *ASO Catalog* does list a small number of standard types. The actuating cylinder can be charged with compressed air and nitrogen as well as CO_2, and when so charged, the cylinders are painted a different color. The actuating cylinder can be used for emergency measures other than lowering landing gear, depending on its designed purpose. For other particular uses consult the *Handbook of Maintenance Instructions* and the *Illustrated Parts Breakdown* for the aircraft concerned.

Table 8–6.—Specifications for nonshatterable compressed gas cylinder, type A

AN part No.	Dimensions					Internal volume, cu. in. min.	Weight, pounds, max.*
	Length	D Dia.	ANPT	E Dia.±1/64	F Min.		
AN6025A53	11–3/8 ± 1/8	2–27/32 ± 1/16	3/8	7/8	3/8	53	2. 75
AN6025A57	9–1/4 ± 1/8	3–45/64 ± 1/16	1/2	1–5/32	9/16	57	3. 63
AN6025A96	13–3/8 ± 1/8	3–45/64 ± 1/16	1/2	1–5/32	9/16	96	5. 19
AN6025A147	18–7/8 ± 1/8	3–45/64 ± 1/16	1/2	1–5/32	9/16	147	7. 44
AN6025A205	14 ± 1/8	5–11/32 ± 5/64	1	1–23/32	3/4	205	9. 31
AN6025A205A	24–1/4 ± 1/4	3–21/32 ± 1/8	1/2	1–5/32	9/16	205	9. 25
AN6025A295	18–1/2 ± 1/8	5–11/32 ± 5/64	1	1–23/32	3/4	295	12. 15
AN6025A386	15–3/8 ± 1/8	6–59/64 ± 5/64	1	1–23/32	3/4	386	14. 94
AN6025A514	19–1/4 ± 1/8	6–59/64 ± 5/64	1	1–23/32	3/4	514	18. 63
AN6025A646	23–1/2 ± 1/8	6–15/16 ± 5/64	1	1–23/32	3/4	646	25. 81

AN6025A853	26-¾±¼	7-11⁄32±⅛	1	1-23⁄32	¾	853	32. 75
AN6025A978	30±¼	7-11⁄32±⅛	1	1-23⁄32	¾	978	38. 00
AN6025A1220	25-¾±¼	9- 7⁄32±⅛	1	1-23⁄32	¾	1220	50. 87
AN6025A1430	29-⅞±¼	9- 7⁄32±⅛	1	1-23⁄32	¾	1430	61. 43
AN6025A2040	40-½±¼	9- 7⁄32±⅛	1	1-23⁄32	¾	2040	83. 50

*For definition and application of drawing status notes, see ANA bulletin No. 337.

The following formula may be used for computing the maximum CO_2 capacity in pounds:

$W=\frac{C}{40.72}$: W=lbs. CO_2 maximum, C=internal volume of cylinder in cubic inches minimum.

Cylinders covered by this drawing are designed for working pressure of 1,800 and 2,100 p. s. i., as applicable.

Plain dash numbers for cylinders having priming coat only and for which no specific use is established.

Add: X after type letter for cylinders used for oxygen, paint green.
 A after type letter for cylinders used for air, paint black.
 C after type letter for cylinders used for carbon dioxide, paint gray.
 D after type letter for cylinders used for carbon dioxide hand portable fire extinguishers, paint red.

Examples of part numbers:
 AN6025AX53=cylinder, paint green, for use with oxygen.
 AN6025AA53=cylinder, paint black, for use with air.
 Dimensions in inches.

Table 8-7.—Specifications for nonshatterable compressed gas cylinder, type B

AN part No.	Dimensions									Internal volume, cu. in., min.	Weight, pounds, max.
	Length	D Dia.	C±.005	D drill size, max.	E	F±.005	G±1/64	H±1/64	J min. full thd.		
AN6025B20	9-1/4±1/8	2±1/16	0.438	3/8	3/8 straight pipe thd.	0.573	1/16	3/16	1/2	20.4	1.25
AN6025B25	11-1/2±1/8	2±1/16	.438	3/8	3/8 straight pipe thd.	.573	1/16	3/16	1/2	25.7	2.10
AN6025B30	10-1/2±1/8	2-13/32±1/16	.438	3/8	3/8 straight pipe thd.	.573	1/16	3/16	1/2	30.6	2.57
AN6025B57	9-9/16±1/8	3-45/64±1/16	.660	33/64	1-1/8-12NF-3	.940	7/64	9/16	3/4	57	3.63
AN6025B96	13-11/16±1/8	3-45/64±1/16	.660	33/64	1-1/8-12NF-3	.940	7/64	9/16	3/4	96	5.19
AN6025B147	19-3/16±1/8	3-45/64±1/16	.660	33/64	1-1/8-12NF-3	.940	7/64	9/16	3/4	147	7.44
AN6025B205	14-3/16±1/8	5-11/32±5/64	.660	33/64	1-1/8-12NF-3	.940	7/64	9/16	3/4	205	9.31
AN6025B205A	24-11/16±1/4	3-21/32±1/8	.660	33/64	1-1/8-12NF-3	.940	7/64	9/16	3/4	205	9.38

QUIZ

1. Navy CO_2 cylinders have serial numbers which are preceded by the designation letter
   a. A
   b. C
   c. D
   d. X
2. CO_2 cylinders are hydrostatically tested every
   a. 2 years
   b. 3 years
   c. 4 years
   d. 5 years
3. CO_2 supply cylinders have a working pressure of
   a. 1,800 to 2,015 p. s. i.
   b. 1,800 to 2,100 p. s. i.
   c. 1,800 to 2,400 p. s. i.
   d. 1,800 to 3,000 p. s. i.
4. The safety disk on a CO_2 cylinder will rupture at
   a. 1,800 to 3,000 p. s. i.
   b. 2,400 to 3,000 p. s. i.
   c. 2,600 to 3,000 p. s. i.
   d. 2,700 to 3,000 p. s. i.
5. CO_2 cylinders are painted
   a. green
   b. gray
   c. black
   d. yellow
6. A black band painted on a CO_2 cylinder indicates that it has a
   a. curved syphon tube
   b. straight syphon tube
   c. flexible syphon tube
   d. hollow syphon tube
7. A black dot painted on the bottom of a CO_2 cylinder indicates that it has a
   a. curved syphon tube
   b. straight syphon tube
   c. flexible syphon tube
   d. hollow syphon tube

8. In the event of accidental discharge, CO_2 cylinders employ a
    a. bypass fitting
    b. two-way fitting
    c. recoil fitting
    d. safety seal fitting
9. CO_2 cylinders are identified as being shatter-proof by means of a
    a. 2-inch white band on the shoulder
    b. 3-inch white band on the shoulder
    c. 2-inch white stripe on the side
    d. 3-inch white stripe on the side
10. CO_2 cylinders are shatter-proofed by
    a. heat treating or wire wrapping
    b. heat treating or purging and drying
    c. wire wrapping
    d. purging and drying
11. CO_2 cylinders used to lower landing gear are identified by
    a. green and black bands
    b. black and red bands
    c. red and green bands
    d. green and white bands
12. CO_2 cylinders used to lower landing gear can also be filled with
    a. helium and oxygen
    b. nitrogen and oxygen
    c. compressed air and nitrogen
    d. compressed air and helium
13. Once a cutter type CO_2 valve has been actuated, with CO_2 remaining in the cylinder it can
    a. always be shut off
    b. never be shut off
    c. seldom be shut off
    d. sometimes be shut off

CHAPTER 9

CO_2 SYSTEMS AND RECHARGING

CARBON DIOXIDE

Carbon dioxide gas was first discovered by J. B. Van Helmont (1577–1644), but it was not until a century later that A. L. Lavoisier (1743–94) demonstrated its nature by burning carbon in oxygen. Carbon dioxide is a component of the atmosphere. It is formed in the process of respiration, in combustion of all carbonaceous material, and in fermentation.

CO_2 (the chemical symbol for carbon dioxide) is a colorless gas, possessing a faint pungent smell and a slightly acid taste. It does not burn and does not ordinarily support combustion. However, metals such as magnesium when ignited will continue to burn in it while giving off oxides and liberating carbon. CO_2 gas is 1.53 times heavier than air and requires only a pressure of 600 p. s. i. below 88° F. to liquefy. It can be condensed into a colorless liquid and stored in this state under pressure in cylinders. When the cylinder valve is opened, gaseous CO_2 escapes and, because of the rapid drop in pressure and temperature, forms carbon dioxide snow. This snow, when compressed into blocks or cubes, is what we know as dry ice. Dry ice, in solid form and at atmospheric pressure (14.7 p. s. i.), evaporates, remaining at $-110°$ F. until it disappears. It is excellent for specialized refrigeration uses.

There are many natural carbon dioxide wells in the earth's surface. Yellowstone National Park has several of these wells. In some caves the CO_2 is so dense that animals are suffocated when they wander into them. Since CO_2, in addition to being heavier than air, is both invisible and odorless, it presents a particular hazard. As in caves, it will tend to collect in low, unventilated places, such as below decks aboard ship. Men encountering these conditions run the risk of smothering to death. Small percentages of carbon dioxide will cause tiredness and perhaps headaches. Experiments have shown that a 3 percent concentration of CO_2 in the air will double the breathing effort, 5 percent will cause panting, 8 percent will cause marked distress, and 10 percent will cause unconsciousness very quickly.

Treatment of exposed personnel includes removal from the CO_2 laden atmosphere, artificial resuscitation, administering oxygen, and keeping the patient warm.

USES.—Because CO_2 will neither support combustion nor form explosive mixtures, it is one of the chief fire extinguishing agents in use today.

The Parachute Rigger's association with CO_2 will be mainly in the area of inflation, aimed at saving lives. This means servicing and maintaining the different kinds and types of gas cylinders involved in the job of providing a quick means of inflating rubberized flotation equipment; namely, collapsible rafts and life vests. Servicing fire fighting equipment, such as the common CO_2 fire extinguisher used on shore establishments and aboard ships, is not generally considered part of the Parachute Rigger's job. However, servicing fire extinguishing systems used in transport and utility aircraft and the equipment used in its distribution is his job, and is one that requires a specialized skill.

PROCUREMENT.—Carbon dioxide is ordinarily procured from local commercial sources. However, in some locations the Navy manufactures its own. It is purchased or accounted for by the POUND, since it is measured in a LIQUID state. Gas (not in a liquid state) is measured on a volume basis and purchased by the cubic foot. Standard CO_2 supply cylinders are designed to contain 50 pounds of the liquid, and the Parachute Rigger can procure it through his supply officer by following normal supply procedures. As an example, an order for 300 pounds of CO_2 would indicate a request for 6 supply cylinders. It would be ordered through CLASS 51 as listed in the *Standard Stock Catalog.* As a general rule, anything used universally throughout the Navy is listed under STANDARD STOCK. Equipment designed for use in aviation is carried by the AVIATION SUPPLY OFFICE. When ordering CO_2 gas which is in liquid form, we refer to the Standard Stock Catalog under class 51. For an aircraft type CO_2 cylinder used in a fire extinguishing system, we must change our reference to class 51 in the *ASO Catalog.* Keep this in mind when ordering gas separately in bulk form. As you have learned, the same rule holds true for oxygen gas.

Life Raft Release System

The CO_2 cartridge is also used to actuate equipment, its charge is regulated to the force needed to accomplish the action. In some life raft release systems the CO_2 charge, once released from the cartridge, actuates a piston fastened to a cable rigged around a pulley. The piston's movement caused by the gas pressure against its face causes movement of the cable attachments and the life raft door retaining pins to open, and the raft cylinder to inflate the raft. The expanding raft pushes the door cover open, while its painter secured to aircraft, prevents the raft from floating away. This action can be brought about by the copilot who is in a position to pull a handle installed in an aircraft frame located directly behind him. Pulling the handle attached to one end of a long cable (the other end of which is secured to the cartridge discharge head at the life raft station) causes the cutter to rupture the disk and release the gas. Figures 9–1 and 9–2 illustrate this action. An ELECTRIC SUBMERSION SWITCH located forward near the bottom of the fuselage will actuate the mechanism automatically in the event the manual control cannot be used or fails for some reason. In any event, the actuating cable tension must be properly adjusted to avoid a premature release. The jettisoning can also be accomplished manually at the door from both inside and outside the fuselage.

It is the Parachute Rigger's responsibility to service small portable fire extinguishers placed in supporting brackets

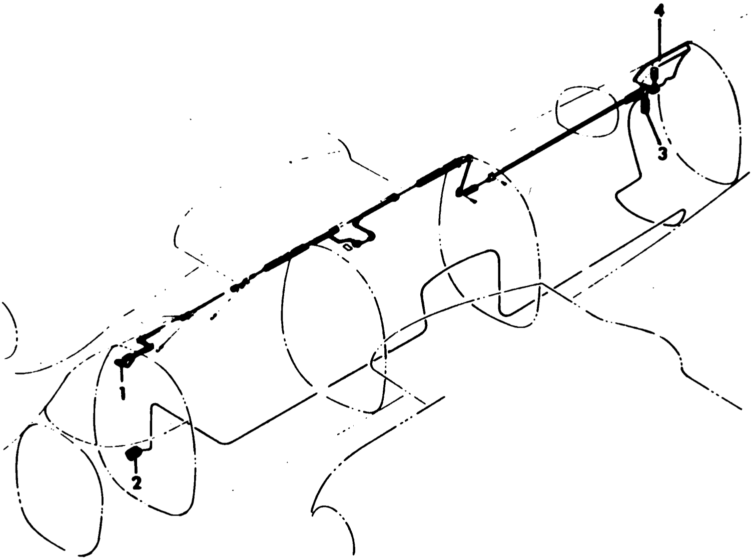


Figure 9–1.—Life raft jettison controls.

1. Life raft release handles.
2. Submersion actuator switch.
3. CO_2 cartridge actuator.
4. Life raft stowage.

about the aircraft. The servicing, maintenance, and operation of this type extinguisher is not complicated. However, the elaborate fire extinguishing systems employed in some of the larger type aircraft are complicated by comparison. The ingenuity of design in the elaborate systems is concentrated on the regions most susceptible to fire. These regions are in and around the engine and fuel cells, but they can encompass larger areas where deemed necessary.

The effects of carbon dioxide on material burning in a confined area, such as in an engine nacelle, are swift and positive in nature. A volume of the area smothered with the noncombustible gas merely displaces the oxygen, and thus prevents further burning. When CO_2 gas can be applied to or remain confined in a burned area long enough, the temperature or flash point of the matter effected will reduce, and no further hazard will recur. However, when

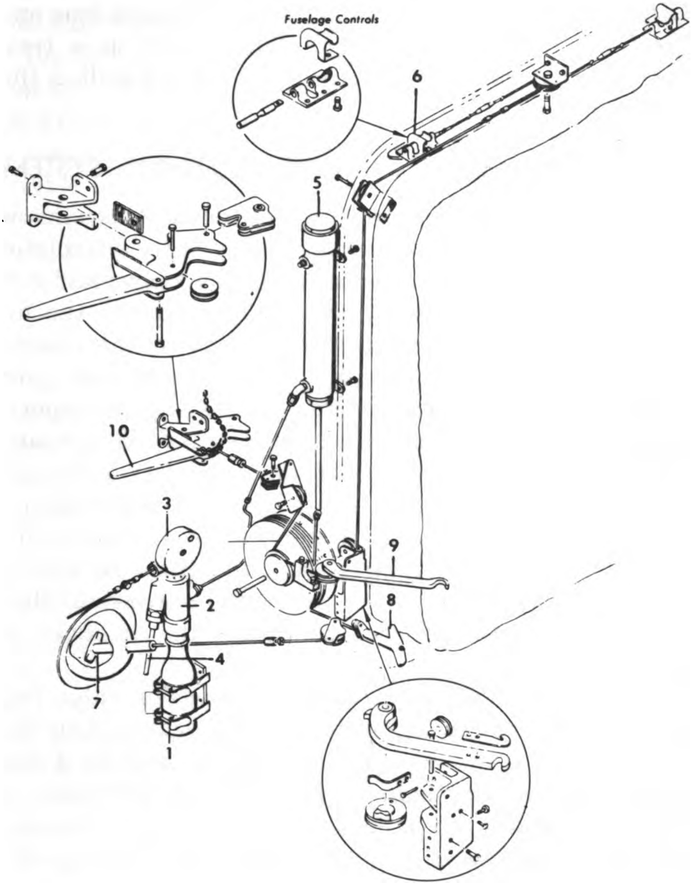


Figure 9–2.—Jettison controls at life raft stowage.

1. CO_2 cartridge.
2. Automatic raft control cylinder assembly.
3. Type H cutter head.
4. Submersion release connection.
5. Long stroke release piston.
6. Release mechanism guide.
7. Release mechanism handle.
8. Release mechanism handle.
9. Life raft release lever.
10. Life raft door release handle.

CO_2 cannot be properly confined within the area long enough, the fire will break out again. This occurs as a result of oxygen reentering the affected area and rekindling the hot material.

FIRE DETECTION AND EXTINGUISHING SYSTEM

The airplane is equipped with a fire detection system which detects the presence of fire and relays this information to the flight station by means of a warning buzzer and warning lights. The extinguishing system extinguishes the fire by smothering it with carbon dioxide. From the description and illustrations of the system to be treated here, you will be familiarized with one system used in a large transport type aircraft. However, the principles involved are the same for most other types, regardless of the complexity of the system.

Nonflammable materials are used in vulnerable locations, such as corrosion-resistant steel plumbing forward of the firewall and fire-resistant materials in the cabin. The cargo compartments are lined with fire-resistant fiberglas. Fire-resistant steel is used to encase the auxiliary power unit.

The presence of fire in the engine nacelles, cabin heaters, and auxiliary power unit is detected by heat-sensing thermoswitches and is indicated at the flight stations by a warning buzzer and warning lights. The switches (detectors) are in various locations throughout the three zones of the nacelles, the cabin heater areas, and auxiliary power unit, and close (make contact) to complete the warning light circuit if the temperature rises to 232° C. (450° F.). Only zone 1 switches close the warning circuit at 316° C. (600° F.). (NOTE: The temperatures given here, and also the system, pertain to one particular cargo-transport type airplane used by the Navy.) The switches reset themselves automatically upon cooling below this temperature. Warning lights for zones 2 and 3 of the power plant are positioned on the fire extinguisher panel. Zone 1 warning lights are immediately below the engine fire extinguisher panel. The cabin heater and auxiliary power unit warning lights are on the lower panel of the station. By careful planning and arrangement of the circuits, the detection system is made as foolproof as possible.

Parachute Riggers who are responsible for servicing a fire extinguishing system as complex as this must understand every aspect of its equipment and its operation. Any responsible electronics technician whose job it is to service the circuits of the fire detection system can check the Parachute Rigger on his understanding of the system and the safety precautions to be observed while working around it.

Fire Extinguishing System

The cargo-transport type airplane is equipped with a two-shot carbon dioxide fire extinguishing system. It is used to extinguish fires in the power plant, the cabin heaters, and the auxiliary power unit. In addition, three hand fire extinguishers are provided in convenient locations in the passenger cabin and flight station. (See figs. 9–3 and 9–4.)

The fire extinguishing system consists of six 12.5-pound cylinders of CO_2 (three per shot) cylinder operating heads, two selector valves, cable controls, six red indicators located flush with the fuselage skin approximately six feet forward of No. 3 propeller, an overboard dump outlet, an auxiliary ground connection, and a distributing system. The cylinders, in this case, are mounted on the right side of the forward lower cargo compartment. Each cylinder incorporates a sealing disk in the operating head which ruptures if the cylinder pressure becomes excessive because of heat. In the event of excessive pressure, the disk will break and a red indicator will be blown off the end of the safety discharge line rupturing a celluloid seal and discharging the gas overboard. This condition indicates that the system should be checked, the trouble corrected, and a new cylinder installed.

If the cylinders are inadvertently discharged by use of the cable control system, the carbon dioxide will exhaust overboard through the bypass (OFF position) ports of the engine and cabin heater selector valves.

Each cylinder is equipped with an operating head. One

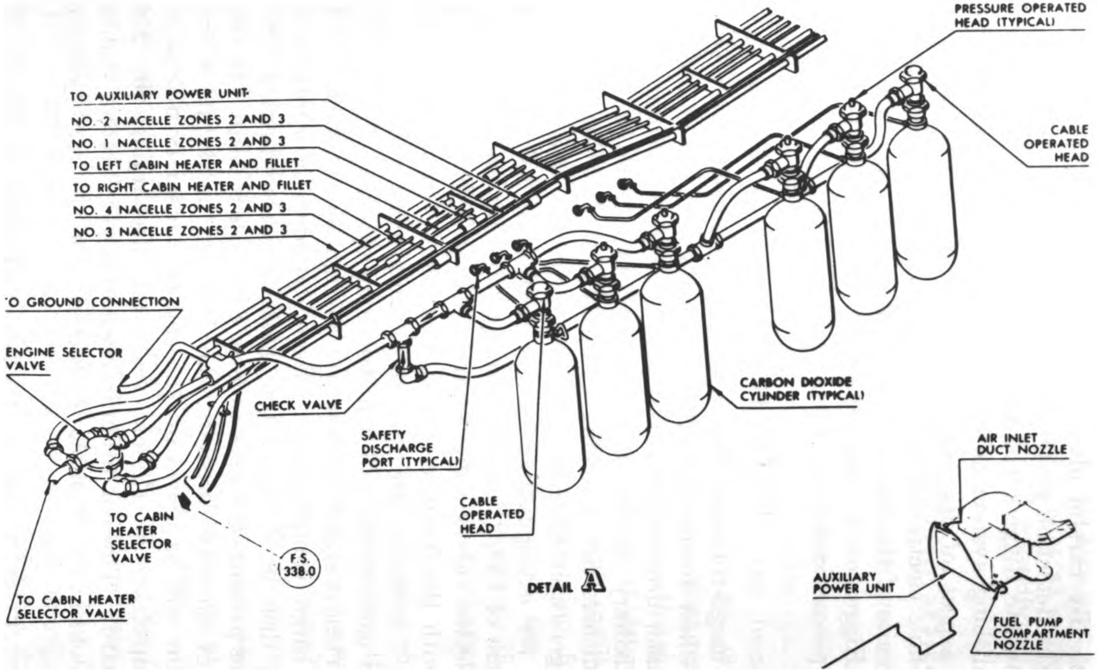

PRESSURE OPERATED HEAD (TYPICAL)
CABLE OPERATED HEAD
TO AUXILIARY POWER UNIT
NO. 2 NACELLE ZONES 2 AND 3
NO. 1 NACELLE ZONES 2 AND 3
TO LEFT CABIN HEATER AND FILLET
TO RIGHT CABIN HEATER AND FILLET
NO. 4 NACELLE ZONES 2 AND 3
NO. 3 NACELLE ZONES 2 AND 3
'O GROUND CONNECTION
ENGINE SELECTOR VALVE
CHECK VALVE
CARBON DIOXIDE CYLINDER (TYPICAL)
SAFETY DISCHARGE PORT (TYPICAL)
TO CABIN HEATER SELECTOR VALVE
CABLE OPERATED HEAD
F.S. 338.0
TO CABIN HEATER SELECTOR VALVE
DETAIL A
AIR INLET DUCT NOZZLE
AUXILIARY POWER UNIT
FUEL PUMP COMPARTMENT NOZZLE

Figure 9–3.—Fire extinguishing system.

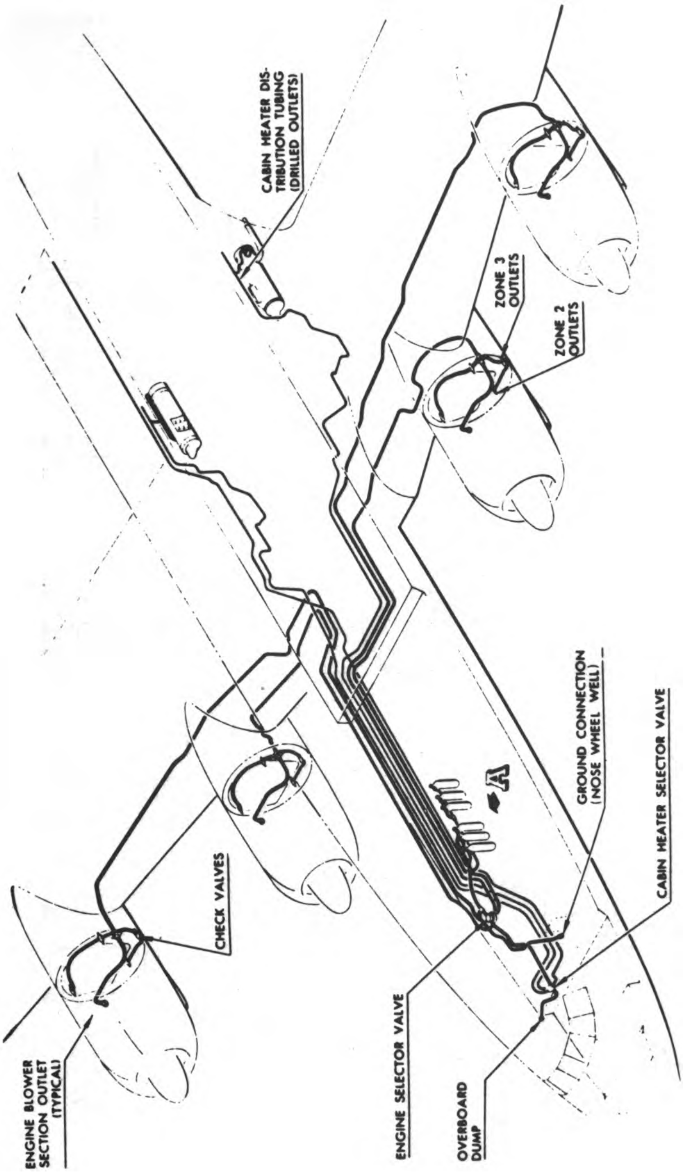

ENGINE BLOWER SECTION OUTLET (TYPICAL)
CHECK VALVES
ENGINE SELECTOR VALVE
OVERBOARD DUMP
GROUND CONNECTION (NOSE WHEEL WELL)
CABIN HEATER SELECTOR VALVE
A
ZONE 2 OUTLETS
ZONE 3 OUTLETS
CABIN HEATER DISTRIBUTION TUBING (DRILLED OUTLETS)

Figure 9-3.—Fire extinguishing system—Continued.

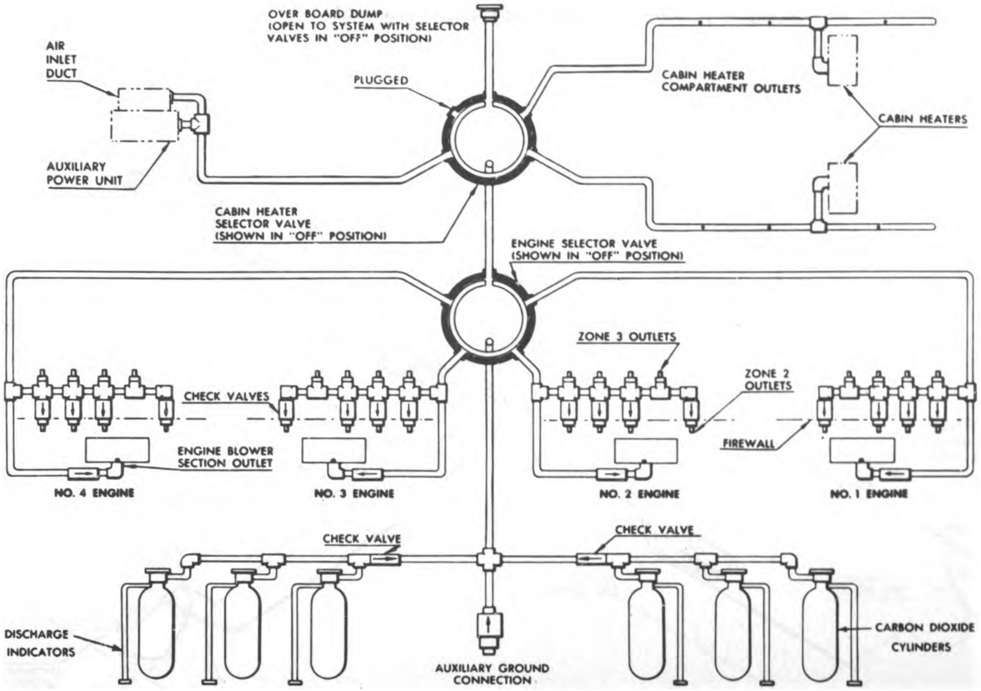

OVER BOARD DUMP
(OPEN TO SYSTEM WITH SELECTOR VALVES IN "OFF" POSITION)
AIR INLET DUCT
PLUGGED
CABIN HEATER COMPARTMENT OUTLETS
CABIN HEATERS
AUXILIARY POWER UNIT
CABIN HEATER SELECTOR VALVE (SHOWN IN "OFF" POSITION)
ENGINE SELECTOR VALVE (SHOWN IN "OFF" POSITION)
ZONE 3 OUTLETS
ZONE 2 OUTLETS
CHECK VALVES
FIREWALL
ENGINE BLOWER SECTION OUTLET
NO. 4 ENGINE
NO. 3 ENGINE
NO. 2 ENGINE
NO. 1 ENGINE
CHECK VALVE
CHECK VALVE
DISCHARGE INDICATORS
AUXILIARY GROUND CONNECTION
CARBON DIOXIDE CYLINDERS

Figure 9-4.—Fire extinguishing system.

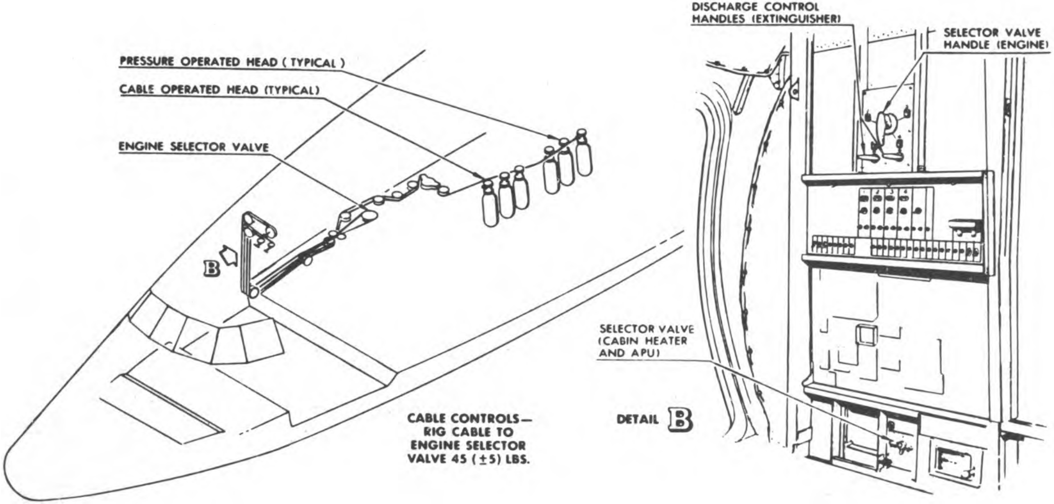

PRESSURE OPERATED HEAD (TYPICAL)
CABLE OPERATED HEAD (TYPICAL)
ENGINE SELECTOR VALVE
B
CABLE CONTROLS— RIG CABLE TO ENGINE SELECTOR VALVE 45 (±5) LBS.
DISCHARGE CONTROL HANDLES (EXTINGUISHER)
SELECTOR VALVE HANDLE (ENGINE)
SELECTOR VALVE (CABIN HEATER AND APU)
DETAIL B

Figure 9–4.—Fire extinguishing system—Continued.

master cylinder, in each group of three, has a cable-operated head which ruptures the sealing disk in the cylinder when actuated by the cable-controlled pull handle on the station's upper panel. The remaining two cylinders in each group are equipped with pressure-operated heads, which rupture the sealing disks when actuated by pressure from the master cylinder. When the sealing disks are ruptured, the gas flows through a check valve to a distribution "T" which routes it to the inlet ports of the two selector valves and the ground connection.

The ground connection is on the right nosewheel well door and incorporates a check valve at the connection.

The engine selector valve is mounted beneath the floor on the right side of the forward cargo compartment, immediately forward of the cylinders. It is controlled by a cable system connecting the valve with the engine selector handle on the station. Before starting the engines, the engine selector valve handle is turned to the respective engine being started. Normally, the valve is in the OFF position. Each selector valve port is piped to a distributing tube mounted on the aft face of the firewall in each nacelle. Nozzles are attached to the tube in such a way as to direct the CO_2 gas forward through the firewall into the four nozzles of zone 2, and aft of the firewall into the four nozzles of zone 3. An additional line is routed forward through the firewall to the engine blower section. A line bypassing through the engine selector valve carries the gas to the cabin heater selector valve when the engine selector valve is in the OFF position.

The cabin heater selector valve is on the station's lower panel. By moving the selector valve handle, gas is directed to the cabin heaters and the auxiliary power unit.

When replacing CO_2 cylinders, be certain that the cylinder used is the vertical mounting type, identified by either a black circle on the bottom of the cylinder or the stenciled letters, INSTALL IN VERTICAL POSITION.

OPERATING CYLINDER HEADS.—Each master cylinder has a cable-operated head. The release cable handles, located immediately below the engine selector valve handle on the station's partition, operate a cable which rotates a pulley in the upper portion of the cylinder head. As the pulley rotates, it causes a red indicator to appear, showing that the head has been operated. At the same time, a cam rotates, forcing the cutter assembly to move down until the primary cutter pierces the sealing disk in the neck of the carbon dioxide cylinder. The primary cutter consists of a small diameter tube. As the primary cutter pierces the sealing disk, carbon dioxide escapes through the center of the cutter to the upper position of the operating head where it exerts pressure against a piston attached to the top of the cutter assembly. The piston then forces the secondary or large diameter cutter through the sealing disk, allowing CO_2 to escape through the outlet port. The outlet port is equipped with a safety discharge valve, closing the outlet, except for a small bleed hole if the cylinder is accidentally discharged when not connected to the distribution system.

The operating heads attached to the remaining cylinders are operated by pressure. CO_2 gas from the master cylinder enters the outlet port of the head, passes through the center of the primary cutter, and enters the upper portion of the head where it exerts pressure against a piston attached to the top of the cutter assembly. The cutter assembly is forced down until the primary cutter cuts the sealing disk of the cylinder. Gas directly from the cylinder now actuates the piston, and the secondary cutter is forced through the sealing disk allowing the carbon dioxide to escape through the outlet port. The outlet port is equipped with a safety discharge valve similar to the one in the outlet port of the cable-actuated operating head. (See fig. 9–5.)

REMOVAL AND INSTALLATION OF OPERATING HEADS.—The method and description presented here is pertinent to one system, and is not offered as a panacea for all systems. Before working on a new system, consult applicable *Handbooks of Maintenance Instructions* and the *Illustrated Parts Breakdown*.

The general outlined procedure follows:

1. Disconnect the control cables from No. 1 and No. 6 master cylinders.

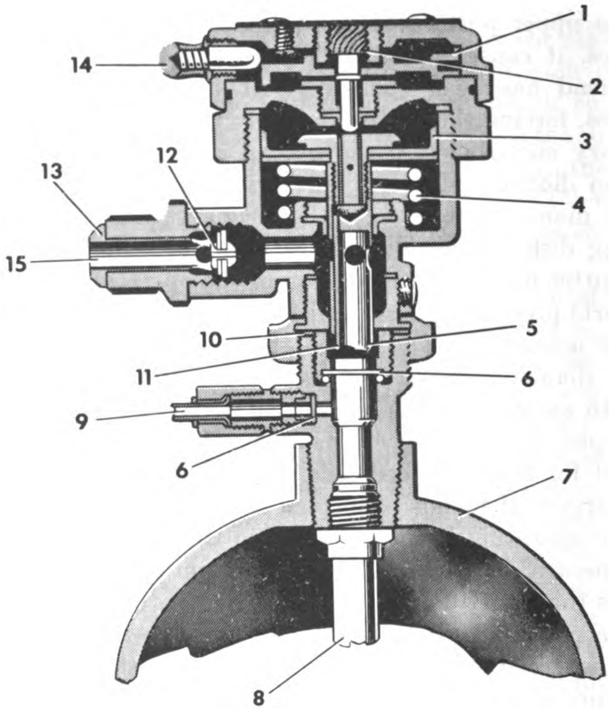


Figure 9–5.—Cable-actuated operating head.

1. **Cable sheave.**
2. **Cam.**
3. **Piston.**
4. **Spring.**
5. **Secondary cutter.**
6. **Sealing disk.**
7. **Cylinder.**
8. **Syphon.**
9. **Safety discharge line.**
10. **Gasket.**
11. **Primary cutter.**
12. **Bleed hole.**
13. **Safety discharge valve.**
14. **Discharge indicator.**
15. **Operating cable port.**

2. Disconnect and cap the carbon dioxide lines.

3. Unscrew the swivel nut on the operating head and remove the head.

4. Install in reverse procedure. When installing the operating head to the cylinder, torque the swivel nut to 90 foot-pounds.

To test the CABLE-OPERATED HEAD proceed as follows:

1. With the head removed from the cylinder, operate it by

rotating the cable drum. The operating force must not exceed 50 pounds. The cable must have free operation for the full length of travel and the cutting-disk travel must coincide with the cable travel. The signal on the side of the unit shall show red after the cable has been pulled. NOTE: The operating force should be checked in the airplane. Operate the control handle in the flight station by attaching a spring scale to the handle and pulling.

2. The operating head is reset by rotating the cable drum in the opposite direction. The red signal shall disappear. The distance between the cutter head pin and the diaphragm must be 1/16-inch minimum.

To test the PRESSURE-OPERATED HEAD, proceed as follows:

1. With the head removed from the cylinder, connect a source of air pressure to the outlet port of the operating head. Gradually apply pressure until the cutter has moved its full travel. The pressure shall not exceed 15 p. s. i.

2. Relieve the air pressure, disconnect the line, and reinstall the head.

For the removal instructions concerning selector valves refer to the aircraft's applicable manuals.

OPERATIONAL CHECK OF THE FIRE EXTINGUISHING SYSTEM.—The operational check as outlined below pertains to the system illustrated in figures 9–3 and 9–4. The procedure follows:

1. Disconnect the CO_2 cylinder supply lines downstream from the check valves on the right side of the forward cargo compartment.

2. Connect an air pressure source to the ground connection. Never exceed 120 p. s. i. air pressure. Use an air pressure source with a moisture trap, filter, and gage.

3. Position cabin heater and auxiliary power unit selector valve to the OFF position.

4. Check for free flow of air from the five outlet nozzles in zone 2. Four nozzles are located around the perimeter of the firewall, and one nozzle leads to the engine induction impeller section.

5. Check for free flow of air from the four outlet nozzles in zone 3.

6. Cap off the inlet to the cabin heater and auxiliary power unit selector valves, and the supply lines at the first connection upstream of zone 3 nozzle ring in each nacelle.

7. Apply air pressure and check for leakage at tubing joints with a mild neutral soap and water solution free from bubbles. No leakage is permitted at tubing joints. A slight external leakage through the engine selector valve is permissible.

8. Reconnect the inlet supply line to the cabin heater and auxiliary power unit selector valve, and the nacelle distributing lines.

9. Place the engine selector valve in the OFF position.

10. Apply air pressure and check for free flow of air from three outlets and one nozzle at each cabin heater, and two nozzles in the auxiliary power unit. The nozzle is located inside the heater valve box and can be checked by removing the cover.

11. Cap off the distributing line upstream of each cabin heater outlet line, overboard discharge at the fuselage outlet, and at the first connection upstream of the auxiliary power unit outlet nozzles.

12. Apply air pressure, checking for leaks at the tubing joints with a mild neutral soap-and-water solution free from bubbles. No leakage is allowed at the tubing joints. Slight external leakage through the cabin heater selector valve is permissible.

13. Reconnect the cabin heater and the auxiliary power unit distributing lines, and the overboard discharge line. Disconnect the air pressure source at the ground connection.

14. Check pull controls on the main station upper switch panel for connection to the proper cylinder.

15. Observe the six red indicators on the right side of the fuselage approximately six feet forward of No. 3 propeller. (A broken red indicator shows the cylinder has been discharged.)

16. Observe operating heads of the cylinders for any visible red signals. (A red signal indicates a discharged cylinder.)

17. Actuate the cutting head while disconnected from the cylinder and using a spring scale at the handle. Do not

exceed 50 pounds pressure at the handle. Reinstall cable-operated heads.

18. Reconnect the carbon dioxide cylinder supply lines downstream from the check valves, and reconnect the pressure-operated heads.

RECHARGE EQUIPMENT

The two most widely used units for transferring liquid CO_2 are manufactured by the C-O-TWO and Walter Kidde Companies of New Jersey. There are others, but for the purpose of this training course we will discuss the setting up and operation of only one of the types mentioned. For more specific information, refer to the applicable manufacturer's manual, following its instructions before attempting to operate the equipment. CO_2 transfer units are carried under class 58 listed in the *Standard Stock Catalog.*

The process of transferring CO_2 gas from a supply cylinder to a smaller utility type is comparable to the oxygen recharging process. Relatively speaking, the differences between the two processes (CO_2 and O_2 transfer) are:

1. Oxygen, transferred as a gas (such is the case where a common compressor type machine is used), is compressed to a higher value and stored in a reservoir cylinder before it is used to boost the final charge.

2. Carbon dioxide, stored in a liquid state, is merely pumped from a supply cylinder to another smaller type.

3. Where the capacity of all cylinders is determined by their internal volume, the state of the gas contained therein determines, in turn, the way the quantity is expressed. Gas in a liquid state is measured by the pound or in so many liquid quarts or gallons etc., while a gas, in a gaseous state, is measured in cubic feet. This measurement is taken by a gas meter. However, in the case of gas contained in a cylinder, the internal volume being known, the quantity is expressed in pounds per square inch. A knowledge of this fact makes it easy to understand the reason for employing a weighing scale in measuring the quantity of carbon dioxide in comparison

with gaseous oxygen, where a pressure gage serves as the measuring device.

Figure 9–6 illustrates the equipment for CO_2 transfer.

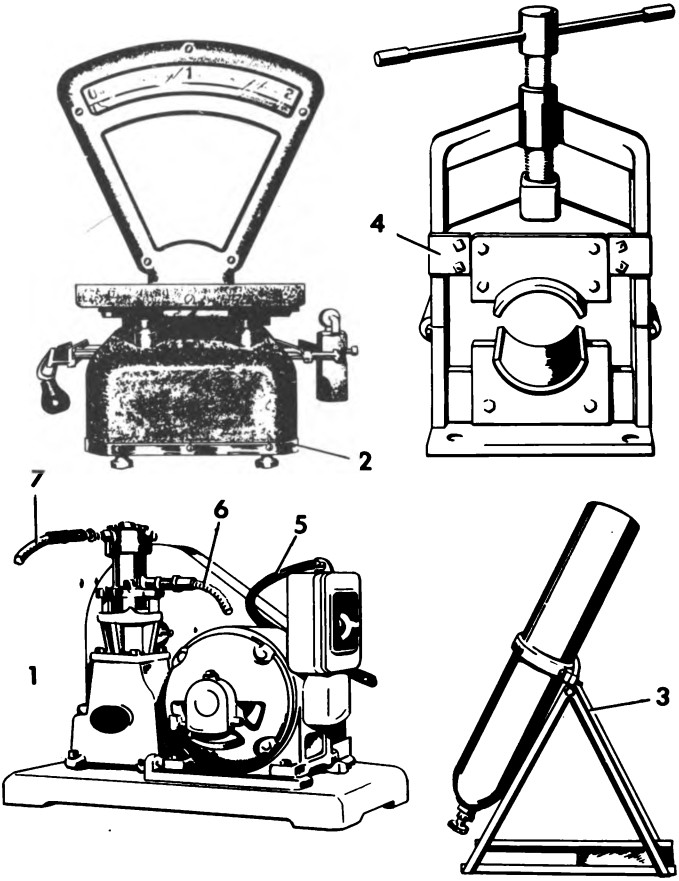


Figure 9–6.—Carbon dioxide recharge equipment.

1. C-O-TWO Pump and Motor. (Power may also be furnished by a gasoline driven engine.)
2. Scale, capable of weighing to 1/100 of a pound.
3. CO_2 supply cylinder and tilt rack.
4. Cylinder type vise.
5. Electric power lead.
6. Hose to lower stage of pump.
7. Hose, pump-outlet to recharged cylinder.

The "Kidde" recharging pump has been designed and manufactured expressly for the purpose of transferring carbon dioxide in its liquid state from one cylinder to another which is to be recharged.

The recharge pump is supplied complete with the necessary adapters, recharging valves, safety disks and bushings, nuts, bolts, and washers for making connections to the cylinder to be recharged, and to the supply cylinder, and for minor adjustments to the unit.

Kidde Model 4211 and 4211–1 pump unit is driven by a ¾ h. p. motor and is equipped with a safety switch and length of flexible cord with a plug suitable for connection in any utility outlet. NOTE: For purposes of safety, it is advisable to use a grounded type plug. Kidde Model 4306 and 4306–1 pump unit is driven by a single cylinder, four cycle, air-cooled engine of 1¾ horsepower.

SETTING UP THE UNIT FOR USE.—The procedure for setting up the unit is as follows:

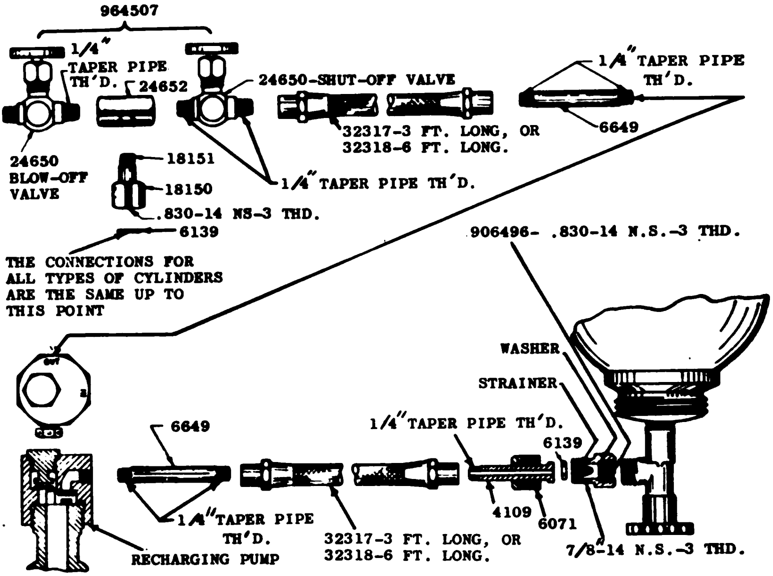
1. Remove crating and examine unit carefully to be certain that no damage has taken place during shipment. Turn master gear attached to crankshaft to be certain mechanism operates freely and make certain that the crosshead clears the packing nut.

2. Fill crankcase with a good grade of S. A. E. 20 oil. ***Caution:*** Do NOT apply oil or grease to the cylinders of the unit or to any of the adapters of hose connections used to carry CO_2.

3. Electrical connections: No special power line is required. Electrical data is printed on the motor nameplate.

4. Start pump, allowing it to run a short time to work oil into the bearings.

5. The arrangement of connecting flexible hose and adapters is shown in figures 9–7 and 9–8. Remove all foreign matter. The inlet and outlet are marked on pump. Assemble the parts as indicated in figure 9–7. Tighten all joints securely with a 10-inch wrench. Do not twist flexible hose. Do not make up coupling nut on strainer adapter



COMMERCIAL TYPE SUPPLY CYLINDER SHOWN (NO SYPHON TUBE). THIS TYPE CYLINDER MUST BE INVERTED, VALVE AT BOTTOM.
WHEN KIDDE SUPPLY CYLINDER (FITTED WITH SYPHON TUBE) IS USED, KEEP ERECT, VALVE AT TOP.
FOR BEST RESULTS KEEP SUPPLY CYLINDER COOL.
SEE RECHARGING INSTRUCTIONS.

Figure 9-7.—Basic flexible hose and adapter connections.

until supply cylinder has been connected as directed later. The strainer adapter is inserted into the inlet line to the pump, preventing dirt or turnings which may accumulate in the supply cylinder from blowing into the pump and impairing the action of the valves.

RECHARGING PROCEDURE.—The supply cylinder which is to be used in recharging must contain dry CO_2 (DRY, meaning no, or practically no water content in the liquefied gas) and must be kept below a temperature of 88° F. Dry (0.05 percent maximum moisture content by weight) and chemically clean CO_2 is an absolute necessity for its successful use in aircraft. If the moisture content is not held to a minimum, by the use of water traps, filters, driers, and similar means, the presence of water will affect the operation of the equipment being charged. It will also cause freezing of the pump during the transfer process.

Standard 50-pound capacity cylinders are generally used for this purpose. When using the standard cylinders, obtain those whose valve outlet passages are at least ⅛ inch, and preferably 3/16 inch in diameter. Before connecting the strainer adapter to supply cylinder, give its valve a "quick blow" by opening the valve momentarily to remove any water caused by condensation or dirt which may have accumulated in the valve outlet.

Many cylinders have a syphon tube extending to the base of the cylinder and these should be used in the upward position or be inclined not more than 60° with the valve on top. Cylinders having no syphon must be inverted with the valve pointed down. (See fig. 9–9.)

The recharge pump designed to pump LIQUID CARBON DIOXIDE is capable of removing approximately 80 percent of the normal content of the supply cylinder. For the most efficient operation, the supply cylinder should be kept at a temperature between 32° and 88° F. If the supply cylinder contains a low percentage of its rated capacity, it may be found difficult to completely recharge a cylinder from it. In this case, a fully charged supply cylinder should be used to put the last "shot" into the recharged cylinder, and the partially charged supply cylinder should be used in starting the recharging of a cylinder which is empty. Following this method, little gas is lost in the recharging process.

If, during the recharging process, the cylinder being charged ceases to gain in weight, there may be one of two things wrong: First, the supply cylinder may contain less than 10 pounds of CO_2, in which case, a fully charged cylinder should be used and the partially charged cylinder be reserved to start recharging an empty one; and second, the connecting lines might become clogged with CO_2 snow. This may be caused by water in the supply cylinder or too small a valve outlet passage (less than ⅛ inch) in the supply cylinder. In this case, the disk assembly (disk type valve) or cylinder valve (seat type valve), should be securely seated and the pump shut off. The connections should be

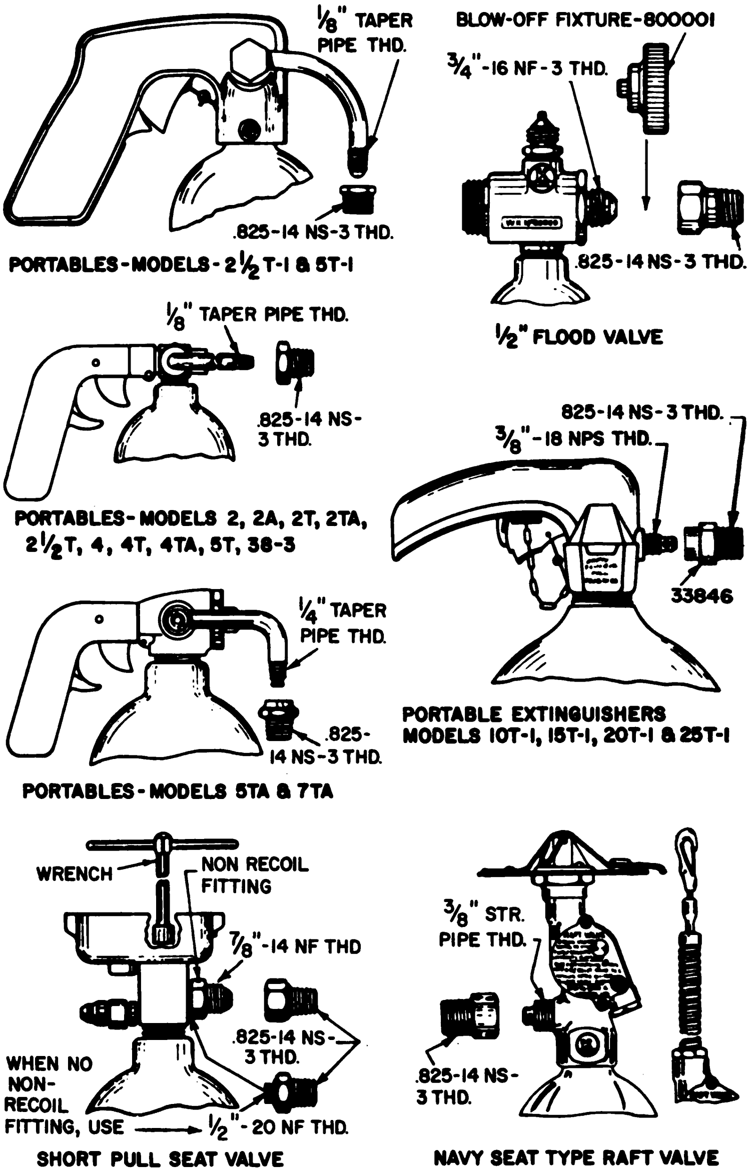
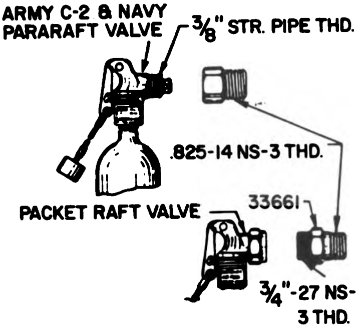
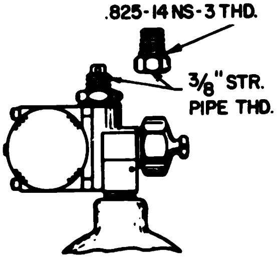


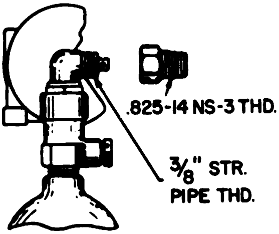
Figure 9–8.—Fittings and charging adapters for various type valves. ***Note:*** **These adapters can be manufactured locally.**



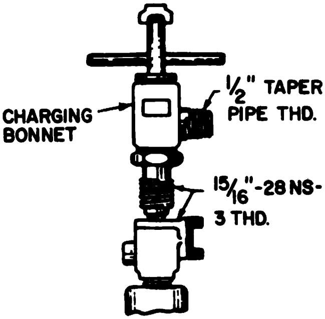
NAVY PARARAFT & PACKET RAFT VALVES & ARMY C-2 RAFT VALVE



AUTOMATIC RAFT-INFLATION VALVE



DROP RAFT VALVE



AUTOMATIC RAFT-CONTROL VALVE

Figure 9-8.—Fittings and charging adapters for various type valves—Con.

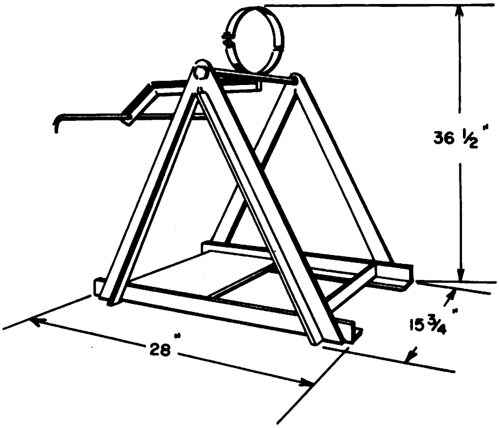


Figure 9-9.—Cylinder tilt rack.

broken (disconnected) and cleared of carbon dioxide snow. The line will clear itself, it allowed to remain inoperative for a time. This can be hastened by applying a flame or torch to the tubing. The line should then be blown out with air to clear it of water and foreign matter.

Cylinders which have been immersed in water while expended must be given a thorough internal inspection and cleaning. This, of course, requires special shop equipment as all traces of water must be removed from the cylinder and valve parts before attempting recharging.

To weigh cylinders whose charging tolerances are very exacting, such as those used with life rafts, a scale reading to an accuracy of $\frac{1}{100}$th of a pound is necessary.

OPERATION.—The procedure for operating the Kidde Unit is as follows:

1. Connect the strainer adapter to the supply cylinder valve and then connect the coupling adapter nut 6071 securely (fig. 9–8). Make up coupling nut 18150 to adapter, charging bonnet, or valve body (depending on type of cylinder to be charged), using washer 6139 between these items. NOTE: The part numbers given here are Walter Kidde's, but serve for identification purposes. Knowledge of a manufacturer's part number is very often necessary when ordering through the Navy's supply system.

2. Be sure the cylinder valve is open and ready for charging.

3. Place the cylinder on a scale and note the reading. It makes no difference what position the cylinder is in when being recharged. Instructions for setting up and operating the scale come with the equipment. If not, write to the company for instructions.

4. Open shutoff valve 24650 fully; make certain blowoff valve 24650 is fully closed. Then start recharging pump.

5. Open valve on supply cylinder fully, keeping constant check on weight of cylinder being recharged. If the suspended recharge hose leading to the cylinder on the scale is touching the floor or stand, the scale will be unable to indicate an accurate reading.

For small capacity cylinders very little time is needed in running the pump. In fact, some operations require that one finger be held on the start button while another remains poised over the stop button, the charge being jockeyed into the cylinder by alternately starting and stopping the pump. Recharging the pararaft cylinder necessitates this kind of operation. Experience is the best teacher; proceed slowly where high pressured equipment is concerned.

6. When the cylinder is charged with the proper weight of gas, stop the pumps and close the shutoff valve tightly.

7. Close the valve on the cylinder being charged. Then open the blowoff valve.

8. Check the final weight of the charged cylinder. If overcharged, blow down to the correct figure.

9. When more cylinders are to be recharged, one immediately after the other, the valve on the supply cylinder may be left open.

10. When the unit is not in use, the valve on the supply cylinder should be closed. The pressure in the recharging pump and connections may be relieved by opening the shutoff valve.

LUBRICATION.—The recharging pump crankcase should be checked periodically to determine the oil level. Drain and renew oil as required. The plunger packing does not require oil.

PLUNGER PACKING.—Refer to manufacturer's manuals for instructions.

CLEANING.—The connections to the recharging pump should be kept free from foreign matter.

If a decrease is noted in the amount of CO_2 transferred (should be about 80 percent of supply cylinder), remove the check valves in the compressor head and clean. To do this, refer to the manufacturer's manuals and drawings.

TIGHTENING.—Periodically tighten all bolts on the compressor head and frame which may become loose from vibration.

The safety disks of the cylinders are painted various colors to identify the pressure at which they will rupture. It is IMPERATIVE that the correct color disk be used in every case. All cylinders are manufactured in accordance with the requirements of the Interstate Commerce Commission. These requirements specify that the cylinder be tested to five-thirds of its nominal working pressure and that the nominal working pressure be stamped on the cylinder immediately following the letters ICC3A. Common cylinder stampings and the corresponding test pressures are as follows:

Cylinder stamping	*Test pressure*	*Color of permissible disk*
ICC3	3,000 p. s. i	White.
ICC3A1800	3,000 p. s. i	White.
*ICC3A2015	3,360 p. s. i	White.
*ICC3A2205	3,680 p. s. i	White or red.
*ICC3A2300	3,840 p. s. i	White or red.

*Some cylinders in each of these categories were originally fitted with green disks. Green disks, however, are no longer available and should be replaced with white disks.

All industrial portables retain the white safety disk. U. S. Navy disk portables use blue disks, and marine type disk portables, which formerly used green disks, now use white disks. The 75- and 100-pound cylinders are covered by special regulations of the I. C. C. and such cylinders are stamped ICC3A2300. This permits the use of a red disk on such cylinders. Each disk will have the required bursting range ONLY when it is used with the correct disk bushing or safety disk retainer. Under no condition is it permissible to use a disk in a valve where it is working in connection with a different type safety disk retainer. Never trim a safety disk down to fit a valve other than the one for which the disk was originally intended. USE ONLY THE PROPER DISK WHEN RECHARGING.

Recharging Winterized CO_2 Cylinders

In connection with the U. S. Air Force winterization program, all carbon dioxide portable fire extinguishers installed in aircraft and all aircraft carbon dioxide built-in engine fire extinguishers are to be serviced to operate throughout the temperature range of −65° F. to +150° F. by "supercharging" with the addition of 200 p. s. i. of dry, oil-free nitrogen. Extinguishers which are to be charged to meet this winterization requirement are identified by a yellow dot ¾ inch in diameter or larger, on opposite sides of the cylinder. Extinguishers so marked are winterized by first introducing nitrogen at 200 p. s. i. and then adding a proper charge of carbon dioxide.

The addition of nitrogen in carbon dioxide cylinders provides additional pressure which expels the carbon dioxide at extreme cold temperatures (below 0° F.) at a much higher rate than would the pressure of the carbon dioxide itself. Winterized cylinders have a carbon dioxide charge less than rated capacity. As a result the total pressure is lower at high temperature than with rated charge, even though nitrogen has been added. Thus, winterized cylinders can be subjected to 150° F. without rupturing the safety disk.

Refer to applicable publications for the special instructions involved in winterizing the charges of CO_2 cylinders.

Recharging Cylinder Equipped With Dual Pull Seat Type Raft Valve

Do not confuse the seat type raft valve with the earlier cutter bonnet types. This valve does NOT have to be removed from the cylinder for recharging. Figure 9–7 illustrates the dual pull seat type raft valve.

RECHARGING PROCEDURE.—The recharging procedure is as follows:

1. Remove the valve cover plate.
2. Reset the sheave by inserting a large screwdriver in the slot and rotating it fully counterclockwise until it stops.
3. Connect the carbon dioxide charging line to the outlet of the raft valve, using adapter (21499).
4. Charge with the proper weight of carbon dioxide as stenciled on the cylinder. Charging line pressure will open the valve; release of pressure will permit the valve to reclose.
5. Disconnect the charging adapter from the valve outlet and check the weight carefully. If the cylinder is overcharged, it must be "blown down" to the correct weight. To do this, insert a screwdriver in the slot on the sheave

and rotate it slowly clockwise until the gas begins to discharge through the nonrecoil outlet. Return the sheave to its fully reset position after the proper weight has been reached.

6. Check for leakage by immersing only the OUTLET in water. Foreign particles on the valve seat can cause leakage, and may be removed by giving the valve a quick short "blow." Make certain to recharge the cylinder to its proper weight if this is done. Remove all traces of water.

7. Reinstall the cable by passing it through the cable opening and around the sheave. It is NOT necessary to remove the sheave to do this. Do not permit the sheave to rotate during this procedure, as this would cause discharge of the carbon dioxide.

8. If the valve is the BuAer drop raft type, make certain that the handle is positioned properly to seat the locating pin in the slot of the cable opening, then set the handle in place and fasten the flap.

9. Before replacing the cover, make certain that the sheave is FULLY reset and that the cable and ball are properly seated around the sheave.

10. Replace the cover. The green indicator should be visible through the window.

11. If the cylinder is to be repainted and restenciled, make certain that the cylinder serial number and weight data are recorded before painting, so that proper weight data will be restenciled on the cylinder.

The instructions for recharging this assembly were presented as an example. For further instructions on other types illustrated in figure 9–8, and for others not even illustrated, see the applicable publications. These publications are listed in the *Naval Aeronautic Publication Index* and its supplements.

QUIZ

1. To liquefy CO_2 at a temperature of 88° or below, requires a pressure of
    a. 400 p. s. i.
    b. 500 p. s. i.
    c. 600 p. s. i.
    d. 700 p. s. i.
2. A large concentration of CO_2 in a confined area will cause death by
    a. freezing
    b. smothering
    c. poisoning
    d. all of the above
3. CO_2 is ordered by the
    a. cubic inch
    b. cubic foot
    c. gallon
    d. pound
4. In the *Standard Stock Catalog*, CO_2 gas is found under
    a. class 27
    b. class 42
    c. class 51
    d. class 83
5. In the *ASO Catalog*, CO_2 transfer units are carried in
    a. class 85
    b. class 37
    c. class 58
    d. class 25
6. CO_2 is transferred by pump in the form of
    a. vapor
    b. gas
    c. solid
    d. liquid
7. A CO_2 pump is constructed to remove from a supply cylinder
    a. 20 percent of CO_2
    b. 30 percent of CO_2
    c. 70 percent of CO_2
    d. 80 percent of CO_2

8. A CO_2 scale is calibrated in
    - a. $\frac{1}{10}$ pound
    - b. $\frac{1}{1000}$ pound
    - c. $\frac{1}{100}$ pound
    - d. $\frac{10}{100}$ pound
9. After a CO_2 cylinder has been recharged it is checked for leakage by placing
    - a. outward end in water
    - b. pump in water
    - c. hand over cylinder end
    - d. tongue over outward end

CHAPTER 10

STANDARD LIFE RAFTS AND EQUIPMENT

MULTIPLACE LIFE RAFTS

The pneumatic life raft, other than the pararaft, is manufactured in a number of different sizes, designed to accommodate survivors at sea. The size of the raft or rafts applicable to a particular aircraft, is determined by the number of the crew, and the passenger accommodations. The pneumatic life raft is a compact assembly, capable of being stowed in a small area. Its inflatable characteristics and stubborn stability at sea offset the fact that it is constructed of rubberized fabric. Although it is not damageproof, the rubberized raft is surprisingly strong. The capacities of the larger rafts range into the thousands of pounds making them capable of sustaining more than double the number of men they are designed to accommodate. There is literally no end to the usefulness of a pneumatic raft; however, its main purpose is its use with military aircraft. Henceforth, where the meaning of the phrase cannot be misunderstood, pneumatic multiplace life rafts will be referred to as life rafts, or simply as rafts.

Construction

General.—The body of the raft consists of an encircling buoyant tube and a fabric bottom, both of type O fabric. The shape and arrangement of the raft and its components are in accordance with Bureau of Aeronautics drawings, applicable to each size. The raft is tailored to form. Not less than six sections are used in the bow, and not less than five sections in the stern, to provide the specified shape. The fabric bottom of the raft is applied without tension across the enclosure formed by the flotation tube and is attached securely to the underside, extending four inches beyond the centerline, all around the tube. Along this attaching line, different widths of tape are applied for reinforcing and finishing off purposes.

SEAMS.—All seams and attachments are secured by self-curing rubber cement or by vulcanization. No stitches are used in the seams or through the fabric of any air-retaining chamber. However, sewing is permitted in the construction of patches, oarlocks, disks, flap seats, cylinder carriers, lifeline supports, handles, and pockets, but not in their final attachment to the raft. The minimum overlap for seams is 3/4 of an inch, and they are reinforced both on the inside and on the outside with type R tape. The tape is applied in such a way that an equal amount (width) is on each side of the seam edge which it covers. The cement is applied in a straight line, parallel to the edges of the tape, and extends approximately 1/8 of an inch beyond the tape edges.

BULKHEADS.—Internal vertical bulkheads divide the flotation tube into two separate compartments. Bulkheads are constructed of type N rubberized fabric and are either hemispherical or conical in design. These dividing walls (bulkheads) are installed amidships, equidistant from the bow and stern, in such a way that the volume of the two compartments is equal. Attachment of the bulkhead's perimeter to the tube is reinforced on one side with type R tape, and on the other side with a hinge of wider type N tape. A 4-inch diameter patch of type O fabric is installed on the bulkhead in a location where the bulkhead is protected against abrasion by the manifold diffusers when the raft is packed in its carrying case.

INFLATABLE SEATS.—An inflatable seat is installed in each Mk 4 and Mk 7 raft. These seats are circular in shape and are constructed of type O fabric. The ends of the seat are tailored to fit the curvature of the flotation tube. Each end is blocked with type N fabric, making the seat an independent air chamber before it is installed. Inflatable seats are independently inflated by a valve. Attachment of the seat to the bottom of the raft is accomplished with a hinge tape of type N fabric, extending the length of the seat tube. This method of attachment allows for expansion, and prevents undue stresses between the bottom of the raft and the seat.

FLAP SEATS.—One flap seat is installed in each Mk 2 life raft and is at least 8 inches wide. The seat is securely attached to the flotation tube, using the patch construction method. It is not cemented flush with the top of the flotation tube, but is located midway between the horizontal and vertical centerline.

OARLOCKS.—The oarlock consists of 7 plies of type O fabric cemented together. The two outside plies on each side are folded outward at right angles to form a base. The fold of the outer plies, which forms the top of the base, is not less than 1½ inches wide; whereas the fold of the inner plies, which forms the bottom of the base, is not less than 1 inch wide. The outside edge of the oarlock is taped with type R tape to make a smooth surface. A patch of type O fabric of sufficient size to extend at least 1 inch beyond each end of the oarlock base, and containing a slot through which the upright section of the oarlock passes, can be sewed or cemented upon the base of the oarlock. After this, it is cemented securely to the flotation tube. This patch, which supports the oarlock, extends 6 inches beyond the base (measured from inboard and outboard of the base); and thus, it protects the flotation tube from the chafing action of the oars. A reinforcing disk of type O fabric is sewed or cemented to the patch at each end of its slot. A No. 11 brass grommet is set in each oarlock, located so that the bottom edge of the hole is 1 inch above the flotation tube. The oarlocks are attached to the flotation tube outside the top centerline in such a position that the upright portion, containing the grommets, are at an angle from the vertical, inclined away from the centerline. An oarlock is also attached to the top of the flotation tube at the stern so that an oar can be inserted through the oarlock and be used as a rudder.

MAST HOLDER.—One mast holder consisting of an upper and lower structure is constructed in each raft. The upper part of the mast holder consists of an oarlock attached in a horizontal position approximately 3 inches above the inside centerline of the flotation tube. The lower part consists of a socket, 4 inches long, made of 2 plies of type O fabric. This, in turn, is cemented to a 4-inch diameter patch consisting of 2 plies of type O fabric. The patch is then cemented to the raft bottom directly in line with the hole contained in the upper part. Together, these mast holder parts can support an oar handle in the vertical position. The handle passing through the upper hole in the oarlock terminates in the socket.

Supply pocket.—A supply pocket is made from type O fabric; and it measures approximately 8 x 8 x 2 inches (inside dimensions). Two large curtain type fasteners (lift-the-dot) are used in its closure. A piece of type R tape, 1⅝ inches wide, is used for sealing the pocket. The tape is applied after the contents have been placed in the bag. The pocket is attached to the flotation tube surface inside the raft by stitching the pocket to a patch and cementing the patch to the tube. Each pocket should be clearly and indelibly marked in ½-inch letters, Supply Pocket.

Supply pocket and bailer.—Attached to each raft, another type supply pocket measuring 10 x 10 x 2 inches (inside dimensions) is constructed from type O fabric. The pocket has a slit extending the full length of its top side which is closed by means of a slide fastener. A loop of semihard spring wire is contained in the seam around the slot so the pocket may be fashioned into a bailing container. It is secured by means of two large curtain type fasteners to a strap cemented to the tube surface so that it can be detached. To avoid loss of the pocket, it is secured to the lifeline by a 5-foot length of type 3 nylon cord. The words Supplies and Bailer are stenciled in ½-inch letters on the pocket. Accompanying this, stenciled in ¼-inch letters, are the words, Knife, Signaling Mirror, Whistle, Line, Compass, Mast Clamp. The location of this pocket, as well as the location of the other pocket, is shown in applicable drawings.

CYLINDER CARRIER.—One cylinder carrier, suitable for holding the CO_2 cylinder securely in position, is provided with each life raft. The carriers are constructed and located in accordance with applicable Bureau of Aeronautics drawings, as are all the other parts, including the main bodies of the rafts.

ACCESSORY CONTAINER.—The accessory container is constructed of type O fabric. The oars and hand pump are among the items included and stowed in the accessory container. They are protected at each end by a wad of felt or cheesecloth approximately ¾ inch thick in such a way as to avoid damage to these items incident to dropping the raft from aircraft. The hammock bed(s) and paulin can be utilized to protect the other items stowed in the container. The following words are stenciled in ½-inch letters on the body of the container: OARS, PAULIN, PUMP, HAMMOCK BED, CORNER REFLECTOR, SMOKE SIGNALS, DYE MARKERS, SPONGES.

LIFELINE.—A nylon lifeline encircles the perimeter of the raft. The line is attached to the raft by means of lifeline loops or supports. Overhand knots tied on the inside of each rope loop are used to prevent the line from running free through the supports. The ends of the lifeline are joined by a square knot with 6 inches of each end extending beyond the knot and sewed to the line. Four inches of slack are allowed in the line between the rope supports. The supports are constructed of type II, 1 inch wide, nylon tape. A strip of webbing 5 inches long is threaded through a slot in a 3-inch diameter type O fabric disk to form a loop 1 inch long. The loose ends are securely stitched to the disk and two rows of stitching are made through the base of the webbing loop. This assembly is then cemented to the top outside quarter of the flotation tube midway between the horizontal and vertical centerlines of the tube. A type O fabric disk, 5½ inches in diameter, with a slot in the center is then cemented over the loop assembly to the flotation tube. Each completed lifeline patch can withstand a 200-pound pull exerted in a direction perpendicular to the base of the patch.

Righting handles.—Three righting handles are attached to the raft. Each handle is constructed of an 11-inch length of type II, ¾-inch type O fabric. The handle is covered by an outer patch of type O fabric extending beyond the edge of the disk and securely cemented to the life raft. One inch of slack is allowed in the attachment to make them easier to grasp. Handles are located as shown in the applicable drawings.

Boarding handles.—Three boarding handles, constructed in the same manner as righting handles, are attached to each life raft as indicated in applicable drawings.

Topping-off valves.—A topping-off valve is installed in each flotation tube compartment of the raft. The topping-off valve is used for hand inflation purposes in conjunction with the hand pump. It also serves as a means for relieving high internal tube pressures that may possibly build up during hot sunny days. Both valves are installed on the same side of the raft, on the top inside quarter midway between the vertical and horizontal centerline 4 inches from the vertical (internal) bulkhead. When installed, the valves are covered completely by a type O fabric flap.

Stenciled instructions relative to topping-off and deflation of the raft are applied on the raft flotation tube adjacent to the topping-off valves. Appearing in ¼-inch block letters, the instructions are stenciled on a white rubber patch as follows:

TO INCREASE PRESSURE

Attach Hand Pump to Valve
Loosen Valve 2 Turns,
Then Inflate Raft
When Desired Pressure Is Reached
Tighten Valve Cap and Remove Pump

TO DECREASE PRESSURE

Open Valve and Bleed Air

Inflation system.—The valve of the CO_2 cylinder is threaded into the exterior fitting of the manifold. Since a large raft is constructed with internal bulkheads (dividing the flotation tube into two separate compartments), the purpose of the manifold is to provide a common means of directing and diffusing the flow of gas from the actuated cylinder to each of the separate compartments at the same time. To do this, the manifold outlets must BRIDGE the internal bulkhead over which they are mounted. Figure 10–1 illustrates the principles of a raft inflation system. Figure 10–2 shows the major parts of a raft assembly.

All exposed metal surfaces which might chafe the raft fabric while in a packed condition should be suitably and securely covered with scrap cloth.

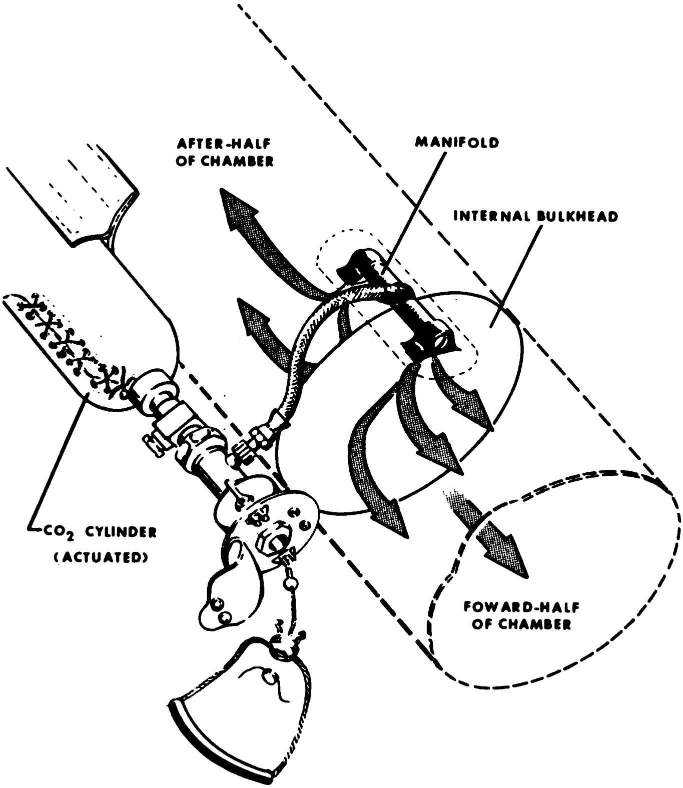


Figure 10–1.—Life raft inflation system.

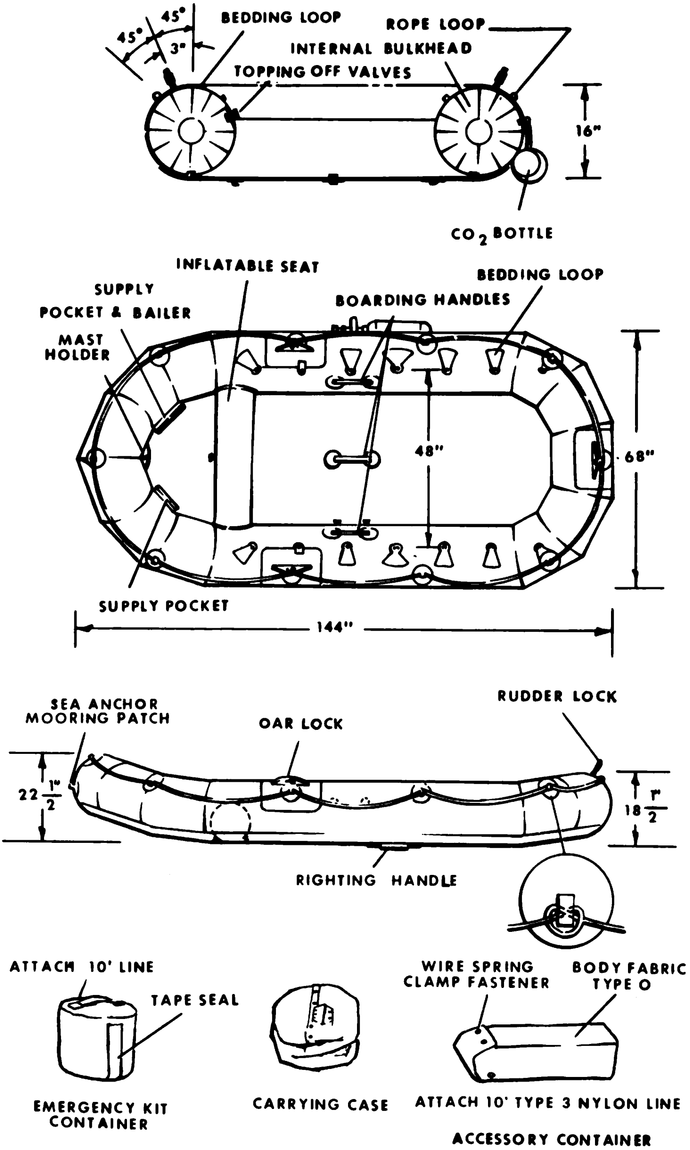


Figure 10–2.—Pneumatic multiplace life raft Mk 7.

USE OF CEMENTS.—Cements used in the construction of rafts are applied to both surfaces of the fabrics to be joined. The application of at least four coats to each surface has been the general requirement. The first two coats of cement are thinned by a suitable solvent which, when worked into the fabric, fill the pores, forming a good adhesive base for the remaining coats. The last two coats are not thinned excessively but are applied using the cement in its normal consistency. Cements are not to be applied to a dirty surface; therefore, before applying the first coat, both surfaces are thoroughly cleaned with solvent. The condition of the cement is controlled during construction of the rafts to insure that old cement or cement partly setup is not used; this fact is significant, since it illustrates the caution that must necessarily be taken in order to obtain a secure bond in the seams and other joined surfaces. Before being refilled, old containers must be free of jelled cement. The drying time allotted between each coat of cement is also very important to the bonding characteristics of the surfaces involved. There will be more on cements later.

Equipment

The equipment used in multiplace life rafts is furnished by two main sources. Some items are furnished by the contractor while others (emergency equipment) are supplied by the government (contracted by the Bureau of Aeronautics). The task and responsibility for outfitting the rafts are divided in three phases; namely, contractor furnished and installed equipment, government furnished and contractor installed equipment, and government furnished and government installed equipment. Information concerning the equipment furnished and installed by the government (Navy) is published in applicable Bureau of Aeronautics *Aviation Clothing and Survival Equipment Bulletins* and other related publications available to all Parachute Riggers. Government furnished equipment (GFE) is assigned a stock number which is listed in the *ASO Catalog* under the applicable class of material. Most of the furnishings installed in life rafts during the manufacturing period are supplied by the government, leaving only the items incident to the rigging and basic operation of the rafts in the hands of the contractor. Only these basic articles will be discussed in this chapter. A review of the equipment which is furnished under the three classification headings as outlined in the specifications will define more clearly the category and initial treatment of the equipment installed in life rafts.

Contractor Furnished and Installed Equipment

OARS.—Three complete oars and one additional oar section (24½ inches long) are supplied for each raft. The oars for the Mk 7 rafts are 6 feet long; whereas, the oars for smaller size rafts are 5 feet in length. All sectional oars (made up of three sections each, A, B, and C) are stowed in the accessories containers of the respective rafts. Figure 10–3 illustrates how a sectional oar is connected. Notice the reflecting material applied to the blade for night use.

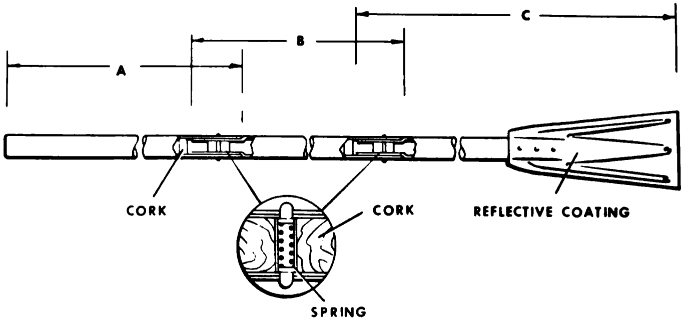


Figure 10–3.—Pneumatic life raft sectional oar.

HAND PUMP.—An inflator pump is supplied with each life raft for emergency inflation. It is stowed in the accessory container and is secured to the grommet in the container by a 3-foot length of type I nylon cord. (See fig. 10–4).

NYLON CORD.—For utility purposes, 100 feet of type I nylon cord is supplied with each life raft. It is kept in the supply pocket of the raft.

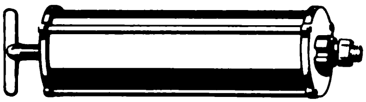


Figure 10–4.—Hand inflation pump.

WHISTLE.—A trill type whistle, attached to a 3-foot securing lanyard, is stowed in the supply pocket. The shrill high pitched trill of a whistle (the kind specified for use in life rafts) can be heard for distances up to 1,000 yards.

BAILING SPONGE.—A type II, size No. 8 (in accordance with applicable specifications) bailing sponge is provided for each Mk 2 raft; whereas, two such sponges are necessary for use in larger rafts. The sponges are used primarily to soak up water collected in the bottom of rafts.

LIFE RAFT CARRYING CASE.—Life rafts are packed in carrying cases constructed of fabric which is coated an orange yellow, corresponding to the color of rafts. The life rafts being of different sizes (2-man, 4-man, and 7-man) require respectively larger size carrying cases to cover them. (See fig. 10–5.) Besides its most obvious capacity, the carrying case is designed to hold the raft in a deflated but ready condition for inflation wherever it is stowed. The closing hems of the case are fitted with snap fasteners, capable of being released in any direction of pull. The tenacity with which these snaps hold the raft in its case must not be too great. The pressures exerted by an inflating raft, swelling in its

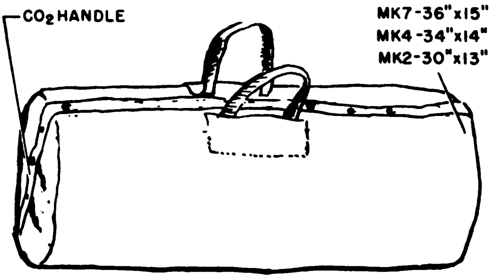


Figure 10–5.—Life raft carrying case.

case, should be sufficient to "pop open" the snaps and release the raft without harm.

RETAINING LINE.—The purpose of the retaining line is to secure the raft to one of the users, thus preventing its loss before and after the raft is inflated. It consists of a 10-foot length of 1-inch webbing and is orange yellow in color. One end is secured to the neck of the CO_2 cylinder while the other end has a snap which can be attached to the life vest retaining loop of the user. Attached to the snaphook is an instruction tag (3½ x 5 inches) of type O fabric. The tag is imprinted with ½-inch letters, and reads: BEFORE INFLATION, CLIP SNAPHOOK TO LIFE VEST. When the raft is packed in its carrying case, the retainer is accordion folded and held in place inside with breakable nylon thread or synthetic elastic bands. The free end of the retainer, with the snaphook and instructions, is rigged to emerge from the carrying case adjacent to the CO_2 inflation handle for quick attachment to the user.

SEA ANCHOR.—A sea anchor is a circular cone-shaped fabric device used for stabilizing or slowing down movements of a vessel in the water. Since a pneumatic life raft, especially when empty, displaces a negligible volume of water, it is moved easily over the water by the wind and currents of the sea. Therefore, one sea anchor of a standard size is provided for use with each life raft. It is used primarily to keep the raft headed into the direction of the wind and waves to prevent capsizing, and in addition it is used to improve the stability of the raft under the conditions encountered when inflating it in a rough sea, during the turbulence of the water caused by helicopter rescue operations, or in checking the drift of the raft over the water. By virtue of the nature of its use, a sea anchor must be securely rigged to a strong mooring purchase. Such a mooring purchase is devised in a patch which, when cemented to the life raft, is capable of withstanding a perpendicular pull of 400 pounds. Being secured to the raft by a length of line terminating in the bridle of the sea anchor, it is dragged submerged through the water. The pressure or resistance created by the water passing through the cone-shaped sea anchor (from its larger

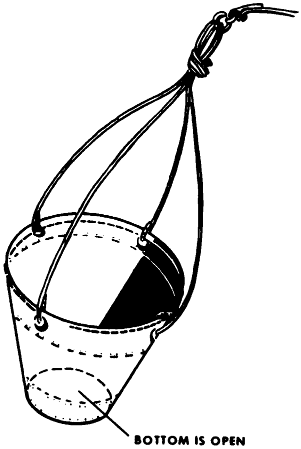


Figure 10–6.—Sea anchor.

end and out the smaller) reduces the movement of the raft over the surface of the water. Figure 10–6 illustrates a life raft sea anchor. The sea anchor is not stowed in some pocket or container, but is rigged to the raft.

Once the raft is inflated, and as an added precaution to prevent loss of the sea anchor in a heavy sea, a strong keeper line (longer than the one attached originally) should be secured between the raft and the sea anchor. IN MAKING THE ADDITIONAL PURCHASE, DO NOT SECURE IT TO THE MOORING PATCH!

HAMMOCK BED.—The raft hammock is suspended between the flotation tubes. The taut canvas provides a means of keeping off the floor when weather and sea conditions are adverse. Water will run off a taut hammock into the raft where it can be bailed out from the vantage point of the hammock. The air space produced by the hammock also protects a survivor from the temperature of the cold water beneath. One hammock is allotted to each 2- and 4-man raft; whereas, two hammocks are needed in the 7-man raft. (See fig. 10–7.) The hammock is stowed in the accessory container.

MAST CLAMP.—The mast clamp is used primarily as an

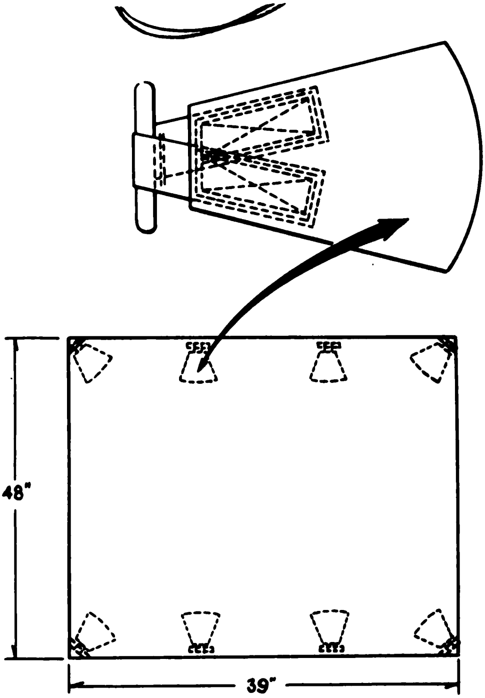


Figure 10–7.—Raft hammock bed.

aid to rigging a sail, and is stowed in the raft supply pocket. In lieu of the mast clamp, nylon cord can be used in securing a cross member to an oar, serving as a mast. The clamp and cord can also be used in securing a distress signal to an oar. (See fig. 10–8.)

Emergency equipment container.—This container is drum-like in shape, having a slide fastener closure installed in one end for admittance of government furnished and installed equipment. Since the three multiplace rafts vary in size, the container sizes also vary to accommodate more equipment needed for the larger rafts. Each container is stenciled in 1-inch letters with the Mark number corresponding to the Mark number of the life raft. A strip of type R tape accompanies each container. This strip is to be used for sealing the slide fastener closure after the container has been equipped. For shipment by the manufacturer, the

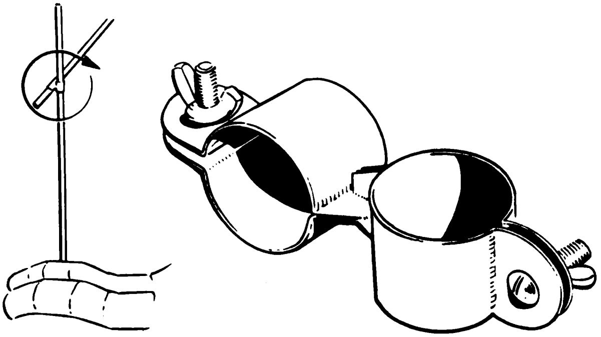


Figure 10–8.—Mast clamp.

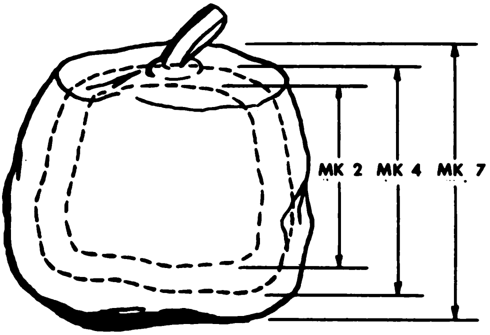
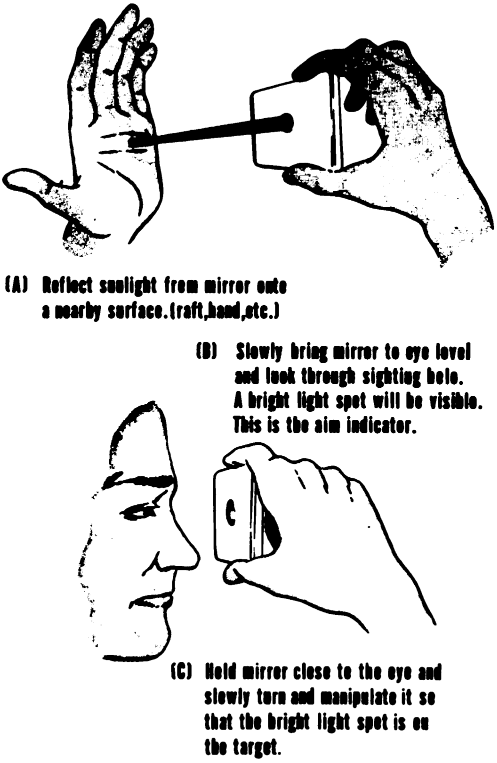


Figure 10–9.—Emergency equipment containers.

empty container is secured to the raft by fastening the snap of the container line to the lifeline of the raft near the CO_2 cylinder. (See fig. 10–9.)

Government Furnished and Contractor Installed Equipment

SIGNALING MIRROR.—The emergency signaling mirror (Mk 4) consists of a metallic reflecting plate and a sighting device. It is used by personnel in life rafts or on land to attract attention of passing aircraft or ships by reflecting sunlight in their direction. The mirror is approximately 5 x 2¼ inches. Its highly polished metal chromium plated surface is capable of reflecting sunlight for many miles, even in hazy weather. The sighting device of the mirror, with a peephole in the



(A) Reflect sunlight from mirror onto a nearby surface.(raft,hand,etc.)

(B) Slowly bring mirror to eye level and look through sighting hole. A bright light spot will be visible. This is the aim indicator.

(C) Hold mirror close to the eye and slowly turn and manipulate it so that the bright light spot is on the target.

Figure 10–10.—Operation of the signaling mirror.

center, contains a fine mesh which is coated on both sides with a wide angle reflecting material. Any light directed at this material is reflected in the darkness. This will attract attention more effectively during night rescue operations than a mirror which may go unnoticed if improperly manipulated under these restricted and difficult conditions.

For protection of the highly polished surface of the mirror, it is placed in a plastic pouch which is fitted with a nylon lanyard and a flap-type closure secured with a button. The mirror is also equipped with a lanyard which may be passed over the head to prevent its loss during signaling operations. Each raft is equipped with one mirror which is stowed in the supply pocket. Whenever possible, pilots and airmen should practice signaling with mirrors available for survival training. In this way, they will become proficient in controlling the direction of reflected sunlight to specific objects.

Before operating the mirror, a protective coating must be removed from its surface. Instructions for using the mirror are imprinted in black lettering on the transparent inside surface of the pouch. Figure 10–10 illustrates the operation of the signaling mirror.

Even though no aircraft or ships are in sight, continue sweeping the horizon, for mirror flashes may be seen for many miles, even in hazy weather.

JACKKNIFE.—The general utility knife supplied with life rafts consists of one large and one small blade, a combination screwdriver and bottle opener, and one can opener. One such knife is stowed in the supply pocket of each raft. A nylon cord lanyard, tied to its ring, prevents its loss. The value of a jackknife, especially under emergency circumstances, need not be emphasized as everyone can visualize its utilitarian possibilities. However, let there be one word of caution—when in the raft, do not let the opened knife dangle from its lanyard.

POCKET COMPASS, MAGNETIC CARD TYPE.—The card type compass is encased in a cylindrical transparent plastic cover, mounted on a flat base. With this type, a circular card swings on a jeweled bearing while a pivot, centered in the base of the compass, supports and suspends the card in its free movement. Inscribed on top of the case is a line of reference. To cage the compass and protect the jeweled bearing mounted in the card, it is stored in an inverted position. In this attitude, the bearing and pivot are not in contact. The compass is reasonably shockproof, but it should be handled with care if one is to expect reliable readings. Damage to the case will impair its waterproof qualities, and promote corrosion in spite of its internal corrosion resistant construction. Fittings outside of the base adapt the compass for wrist wear. The magnetic card type compass is stowed in the supply pocket of each raft.

CORNER REFLECTOR.—A collapsible corner reflector (cluster type) is used on life rafts to increase the range of radar detection. The reflector has the property of reflecting back to the source a large portion of the radar energy that strikes it. Each corner reflector is composed of three planes which intersect at right angles. A beam striking into a corner reflector will bounce off (be reflected) each plane as shown in figure 10–11, finally returning in the direction of its source.

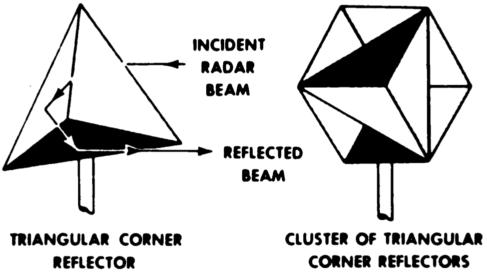

INCIDENT RADAR BEAM
REFLECTED BEAM
TRIANGULAR CORNER REFLECTOR
CLUSTER OF TRIANGULAR CORNER REFLECTORS

Figure 10–11.—Triangular corner reflector.

The effective area for this unit of triple reflection depends on its direction (which way it is facing) in relation to the transmitted radar beam. Therefore, a single reflecting unit will be effective only for directions of energy that cover one octant of a sphere measured from the center of the reflector. By designing a cluster of light reflecting corners, each composed of three perpendicular planes, it is possible to receive and return radar beams in all directions. This is important for the most effective detection of a target reflector, mounted in a small raft afloat in the great vastness of the open sea.

The corner reflector, also known as a "target" reflector and used in life rafts, is an umbrella-like antenna made of eight triangular planes of monel metal mesh that intersect each other at right angles. It can be detected by typical radar equipment, operating between two and eighteen miles from the reflector. One MX–138A corner reflector, used on MULTIPLACE LIFE RAFTS, is stowed in the accessory container. The sealed cartons containing these reflectors are not to be opened except for actual emergency use. Each carton is provided with a short lanyard for securing it to the accessory container, which, in turn, is secured to the life raft.

Although corner reflectors are manufactured according to specifications, certain minor variations (latitude in manufacture) in the details of construction, which do not materially affect their operating characteristics, are permitted. Realizing this, the following procedural steps are given as a general guide and are not to be considered as being inflexible rules. They are presented to familiarize the Parachute Rigger with the general erecting procedures for the MX–138A and/or the MX–138A/A corner reflectors.

1. After removing from carton, tie end of securing line to raft and remove taped paper collars from each end of reflector.

2. Unwind the steel stay cable having an unfastened hook at its end.

3. Unwrap wire mesh carefully from around metal arms. Shake reflector gently and pull outward slightly on each arm to free mesh planes.

4. With hub toward you, grasp the two arms, having red painted ends, near the hub and pull down until they are at right angles to the hub; at the same time, pull on the arm, to which the stay cable will be attached (instruction tag is tied to this arm), until it is also at right angles to the hub.

5. Holding the three arms at right angles (near as possible to right angles), brace end of arm to which tie cable is attached against toe of shoe and flip reflector open.

NOTE: Since the planes must be stretched rigidly in order to function properly, one or two of the aluminum arms might tend to bow under the tension as the reflector is brought to its full open position. The bowed condition of the arms will not affect the function of the planes. However, a kink in any one of the tube arms can weaken the tension on the planes and cause a sagging condition.

6. Insert hook on stay cable in eyelet on opposite arm to hold reflector open and under tension.

7. Connect two sections of oar handle to form mast and slip end through loop in stay cable. Mount reflector on mast, making certain that it is secured firmly.

8. Force rubber oar collar over free end of mast, working it along a short distance. Slip end of mast through mast holder on raft.

With end of mast through the raft holder, force on a second rubber collar. Slide it up and out of the way. Step end of mast in cup on raft bottom. Now, adjust the two rubber collars, one on top of the holder and the other on the bottom, so that the mast is forced down against the bottom of the raft. (See fig. 10–12.)

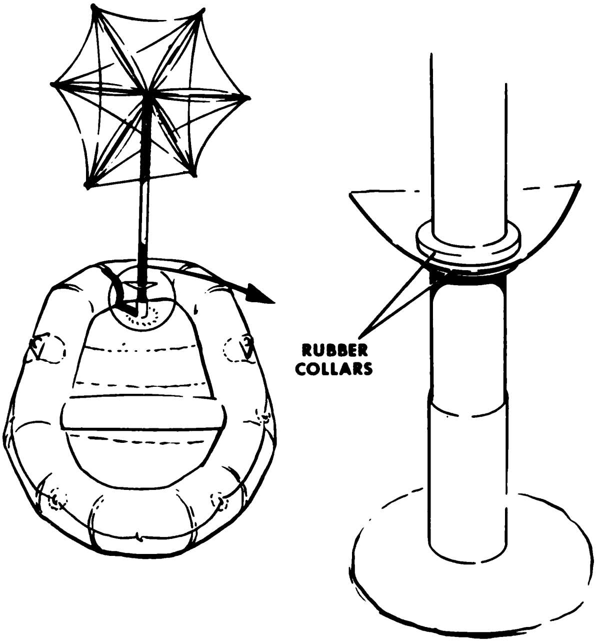


Figure 10–12.—Method of securing mast of corner reflector to life raft.

9. The mast places the reflector at a proper height for air search, but when a surface vessel is sighted add all extra sections of oar handle to mast and hold reflector as high as possible. Do NOT WAVE REFLECTOR.

Caution: The effectiveness of a corner reflector depends on the accuracy of its right-angled corner. Do not tear, warp, or distort its planes.

WATER STORAGE BAG.—The bag is made of a strong transparent pliable plastic and will hold five quarts of water. The open end is reinforced and is designed to hold itself in a closed position. To seal the bag, use must be made of the strap and buckle located near its end. The bag can be sealed tightly by rolling or folding its opening for a short distance, and by securing the folds with the strap and buckle. (See fig. 10–13.) A loop for utility purposes is located on one side of the bag. When the bag is not being used to hold fresh water, it can be used to enclose a pistol or items in need of protection from salt water. Protecting articles in this manner can lead to contamination; therefore, articles should be wrapped in something to prevent lubricants and other contaminant from coming in direct contact with the interior of the bag. Water storage bags are stowed in the equipment containers of life rafts; 2 bags in the Mk 2, 4 in the Mk 4, and 7 in the Mk 7.

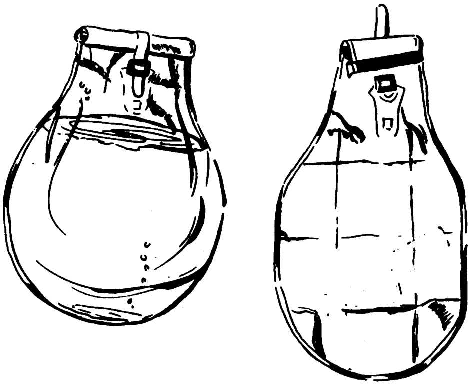


Figure 10–13.—Water storage bag.

DYE MARKER.—The dye packet contains a small quantity of crystalline dye compound (3 to 3¼ ounces). When the compound is exposed to water it slowly dissolves while producing a brilliant yellowish-green fluorescence. Fluorescein dye is very effective for marking a relatively large area which can surround or trail (depending on sea and weather conditions) personnel who are adrift at sea. · Under moderate sea conditions, it takes from 20 to 30 minutes for the dye to dissolve, and after a period of one hour it loses its value completely. Under good conditions and while the marker lasts, it can be seen from a distance of approximately 10 miles at 3,000 feet altitude.

An exterior orange-yellow envelope (6 x 5 x 1 inches) serves the purpose of (1) providing a waterproof container for the dye compound contained in a loosely woven bag; (2) acting as an anchoring point for the dye pouch which is secured to a long tape; and (3) supporting a tape across the top of the envelope which is used to tie the marker to life vests and other basic items of survival. The accessories container of each size raft is supplied with six markers. Figure 10–14 shows the exterior and interior views of the dye marker.

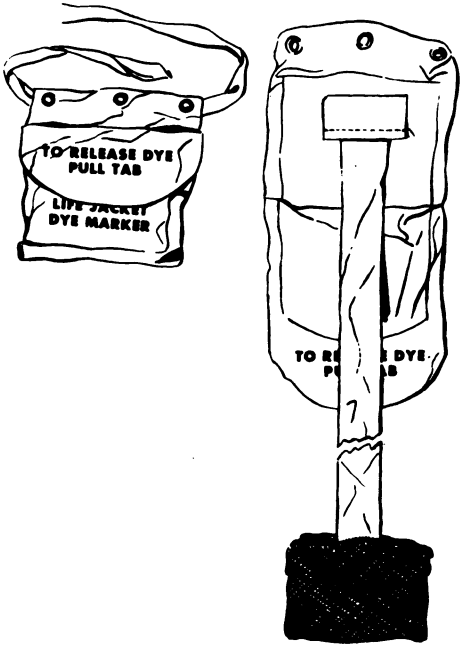


Figure 10–14.—The dye marker.

Emergency signaling code.—The Ground/Air Emergency Code was designed to establish an international means of communication by the use of symbols between survivors and search and rescue parties. Its instructions and illustrations, printed on tough water resistant paper, outline a series of conditions relative to emergencies in connection with disabled aircraft, medical problems, landing instructions for the rescuing party, etc. A life raft paulin, the person or persons themselves, strips of cloth, sticks and stones, or anything available can be used to create the symbols corresponding to the conditions relative to the predicament illustrated in the code. In acknowledging the signals as being understood, or not understood, the rescuing airplane will follow the instructions printed in the code. Every life raft (multiplace) is supplied with one of these codes which is stored in the supply pocket. The importance of the code is illustrated by the number of survival items which are equipped with it. One copy of the code is inserted in the inspection data pockets of all parachutes. The chest type parachute loses its pack upon opening; therefore the parachute is specially equipped with a code pocket located on the yoke of its lift web assembly. Droppable sealed type kits, which cannot be opened before use, should have a copy secured to one of their handling straps. A copy of the code must also be made available in navigation chart boards, and in places where chart boards are not used. The code may also be posted in the flight compartment of aircraft.

DESALTING KIT.—The average man can survive for a long period (sometimes as long as 30 days and more) without food, but he cannot approach this time without water. The chemically activated desalting kit was developed for making small quantities of sea water drinkable. Before the chemical kits were made available, fresh water was contained and stowed away in pint-sized cans. The cans of water posed many problems (cumbersome, weighty, became unpalatable with age, invited rust, etc.), which the desalter kits partially eliminated. Although the kits represent a great advancement, their potential is limited to the number of briquets that are packed in them. Each briquet makes about a pint of drinkable water.

The desalter kit, weighing 1¾ pounds, consists of a hinged metal container with retaining lanyard, seven or eight wrapped packs of desalting chemical, a plastic bag for processing the water to be desalted, and a length of mending tape.

The seven or eight packs of desalting chemical, bag, and tape are attached to a nylon tie tape, to each other, and to the metal can. (See fig. 10–15.) Kits are stowed in the equipment container of multiplace rafts; the number of kits assigned corresponds to the Mark number of the raft. For example, the Mk 4 raft, designed to accommodate four men, is assigned four kits.

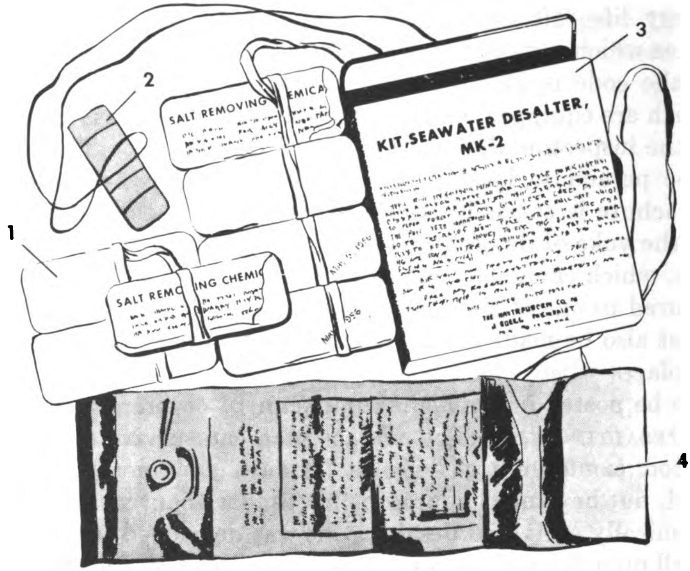


Figure 10–15.—Sea water desalting kit.

1. **Chemical briquets.**
2. **Mending tape.**
3. **Container or can.**
4. **Plastic bag.**

Rinsing the plastic bag before using it, helps to decrease its vinyl taste which is transmitted to the water during the treating process. The treatment is purposely adjusted to leave a little salt in the desalted water to compensate for perspiration losses. If a less salty taste is desired, a smaller amount of water can be admitted into the bag. In this case, the bag can be filled to about an inch below the filling line. An example of the use of the kit follows:

1. Screw plug into outlet tube at the bottom and fill bag to line with sea water.

2. Take out one package of chemical and close container.

3. Remove outer wrapping of briquet, tear off one end of transparent inner wrapping, and pour all of the chemical into the bag of sea water.

4. Fold the top of the bag down tightly, rolling it towards the buckle and strap to make a watertight seal.

5. Permit the chemical to stand in the bag for a few minutes, and it will disintegrate.

6. Further pulverize the chemical by kneading it gently for 15 minutes.

7. Shake the bag gently for 30 minutes.

8. To drink the water, unscrew the plug from the tube located at the bottom of the bag, being careful not to squeeze the bag. Put the tube in the mouth, and gently squeeze the bag or suck on the tube. Spit out the first few drops if too salty.

9. When finished drinking, replace screwplug. The remaining water can be left stowed in the bag.

10. When all the water has been drawn from the bag, rinse out the chemical with sea water. The bag is then ready for reuse.

11. In case the bag becomes damaged, dry the affected area carefully and apply a patch of the mending tape provided.

If the plastic bag becomes damaged beyond repair or is lost, the metal container can be used. In this case, fill the container to the line marked on the inside. Then add one package of the chemical and shake the can gently for 30 minutes. Drink the water through an emergency filter, made by holding a piece of cloth over the top of the can.

SOLAR STILL.—The ability of the solar still to produce drinkable water from sea water depends primarily on two things: First, appropriate weather conditions; and second, its mechanical and physical condition. It is one of the most reliable means by which man is assured an adequate supply of fresh water while at sea.

The solar still was designed to be used by personnel

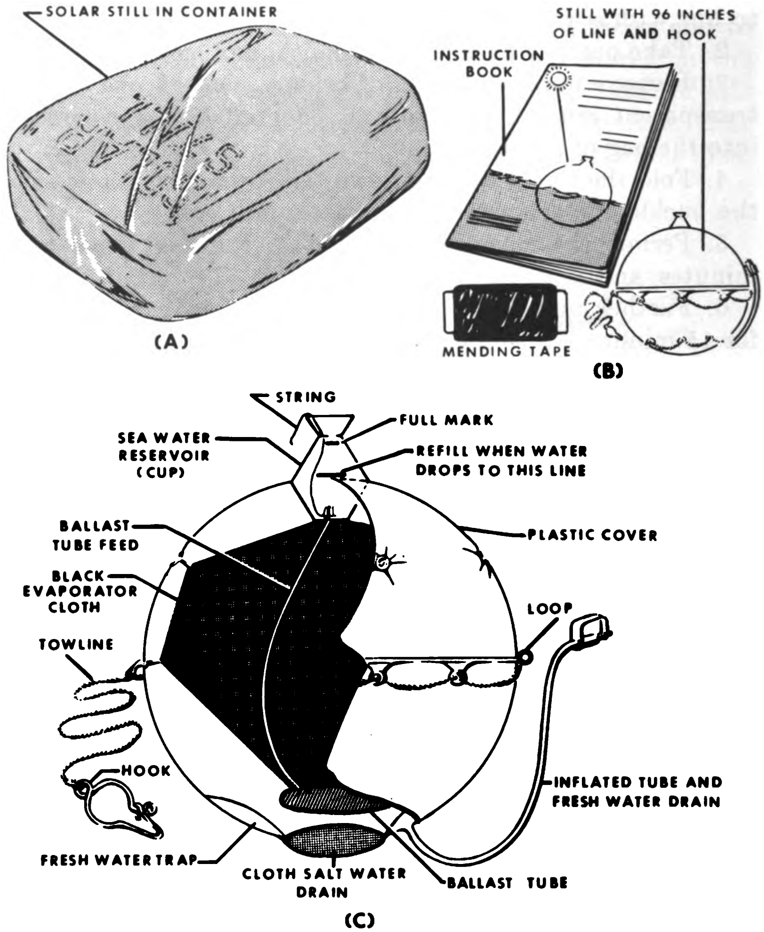


Figure 10–16. Solar still.

aboard life rafts for distilling salt water. The water obtained is fresh and pure, and although it may have a harmless plastic-like taste, especially when the still is first used, one can survive on it. The first distilled water may be milky because of the talc which is sprinkled on the inside of the bag at the time of manufacture to keep the plastic from sticking together. This water is harmless. With care, the still can be used indefinitely as a source of drinking water. Figure 10–16 (A) illustrates the solar still in a packaged condition; (B) shows the contents of the kit; and (C) illustrates its component parts.

The procedure for operating the solar still follows:

1. Wet cloth drain thoroughly. This prevents air from escaping through the cloth until it is inflated. The cloth then acts as a safety valve so that the still cannot be over-inflated.

2. Inflate the bag through the tube located at the bottom until the bag is round and firm as shown in figure 10–17. The suspension points should indent, indicating that the still is properly inflated. Kinks in the inflation tube will prevent inflation. When the bag is inflated excess air escapes through the cloth.

3. Place the still in the water, and while holding it up-

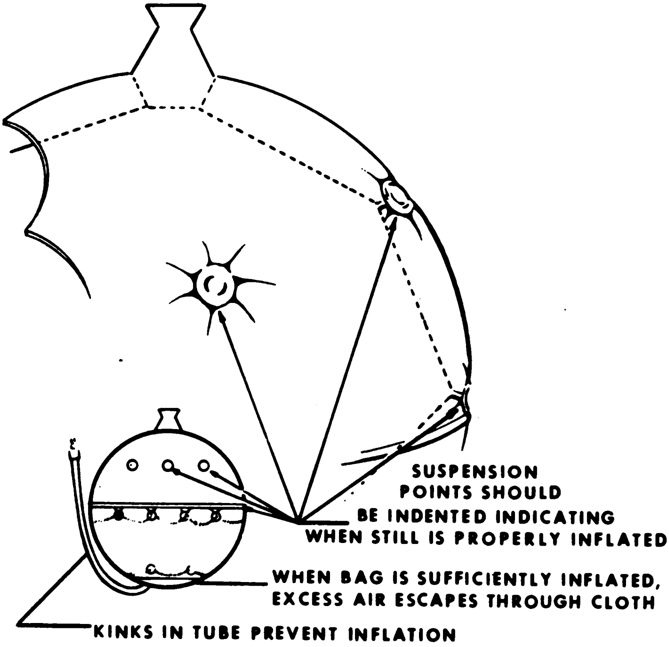

SUSPENSION POINTS SHOULD BE INDENTED INDICATING WHEN STILL IS PROPERLY INFLATED
WHEN BAG IS SUFFICIENTLY INFLATED, EXCESS AIR ESCAPES THROUGH CLOTH
KINKS IN TUBE PREVENT INFLATION

Figure 10–17.—Inflate still until suspension points indent.

right, fill until the sea water in the cup at the top remains at the full mark. When the ballast tube is full, the still will float in an upright position without holding.

4. The still is now ready for operation. Keep it in the sun and away from shadows. Drain out the first two-hour yield when it is used on the first day. Make certain that the securing hook is closed and properly attached to the life raft.

5. Refill when water drops to bottom mark on cup. This should be necessary about once every hour and a half.

6. Keep the still firmly inflated. If permitted to become flabby, the black evaporator material will touch the interior surface of the still and contaminate the freshly evaporated water with salt.

7. Remove fresh water through tube at least three times daily. The water can be sucked out of the tube or drained into the water bags furnished with the raft.

8. When more than one still is in use from the same raft, hook each one securely to another and let them play out in train.

9. When operating, the still has a silvery appearance which is caused by condensation of fresh water on the inside of the bag. If the upper half of the bag loses its silvery appearance in spots, pull on the string located in the cup to clear the water feed of foreign matter. The salts do not evaporate, but remain in the black cloth until washed out through the bottom drain. Since the still is self cleaning, it does not need to be washed out by manual means.

10. In preparing to deflate the still, turn it upside down until the water runs out and the ballast tube is empty. Rubbing the cloth at the bottom with a dry cloth makes the still easier to deflate when pressure is applied to collapse it. The tube, of course, must be open.

11. When the still is put in use after deflating, it should be drained of fresh water after the first 15 minutes to remove any salt water which may have accumulated inside the still after it was deflated.

12. While the solar still is surprisingly strong in most respects, it can be cut easily. Therefore, care should be

taken to avoid having them come in contact with sharp objects. If the still is cut, it should be repaired immediately with the mending tape. This is applied in the same manner as adhesive tape. The place to be patched and the tape must be dry and clean before application of the tape.

The still can produce more than two pints of fresh water daily. Although it needs direct sunlight to operate most efficiently, it will function to some extent if the overcast sky is not too heavy. It will not work at night or on very dark days. The still is not the only source of drinking water. Other sources are rain and the chemical desalting kits. The desalting kits should be saved for possible emergencies; and when it becomes necessary to use them, extreme care in rationing the water must be exercised. Remember, the average man can survive on as little as one pint per day.

Solar stills are stowed in the emergency equipment container. The number of stills provided for each raft is determined by the size of the raft (7 stills for the Mk 7 raft).

LIFE RAFT PAULIN.—The life raft paulin is a rubber coated (neoprene), nylon base cloth, which when laid out flat is rectangular in shape. A 1¾-inch hem around the perimeter of the paulin reinforces its edges and supports a series of grommets. The grommets are provided for utility purposes which make it possible to lace the paulin into many shapes for use as a cover, sail, raincatcher, or anything else devised for the occasion. The all-purpose cover, as the paulin is sometimes called, can also be used in connection with signaling (as outlined in the code), and camouflaging (to cover the orange-yellow color of the raft) as the paulin is dyed neon red on one side and nonspecular blue on the other. With the appropriate side of the paulin stretched across the raft, the nonspecular blue blends into the color of the sea and prevents the occupants from being sighted by enemy aircraft.

Numerous circular reinforcing patches located inboard of the hems offer themselves as strong points of contact. They were designed to be used, wherever possible, as chafing areas which, when brought into play with oar ends, stakes, and items of that nature, would prevent damage to the remaining body of the cloth. Positioned slightly off center and located closer to one end of the paulin is a water collecting device which is used as a drain spout. Rain water collected in the paulin need not be poured from its side, but can be better controlled by opening (untieing) its spout and directing it into the mouth of a water storage bag. The 30-inch length of type III nylon cord is attached to the waterspout for rigging and security purposes.

Life raft paulins are supplied in three sizes. The Mark number of the paulin corresponds to the Mark number of the raft. For example, a Mk IV paulin (approximately 72 x 109 inches) should be used with a Mk IV multiplace life raft. One is stowed in the accessory container of each life raft. Consult the latest applicable publications which outline the stowage locations for life raft emergency equipment. Some of these articles may be stowed in alternate locations.

DISTRESS SIGNALS.—The Mk 13 Mod 0 distress signal is a pyrotechnic torch that burns approximately 18 seconds. It produces a red glow for nighttime use and an orange smoke for day use. Besides being used as a device for attracting attention, it may also be used to indicate wind drift for helicopters performing rescue operations. To ignite the signal, select the appropriate end of the cylinder. The night flare can be identified by the instructions printed around its end; but since these instructions cannot be read in darkness, the night end can also be identified by touch. To prevent the use of the wrong signal and to provide a means of distinguishing the flare end of the signal at night, a series of small bead-like projections are embossed around its circumference. The procedure used to ignite one end of the distress signal is shown in figure 10–18. Hold the ignited signal at arm's length and at about a 30-degree angle from the raft. Do not permit any of the burning contents to drop on your person or on the raft.

Each raft is supplied with 6 distress signals which can be stowed in the ACCESSORY CONTAINER.

FIRST AID KIT.—One kit is used with each of the multiplace life rafts and is stowed in the emergency equipment container.

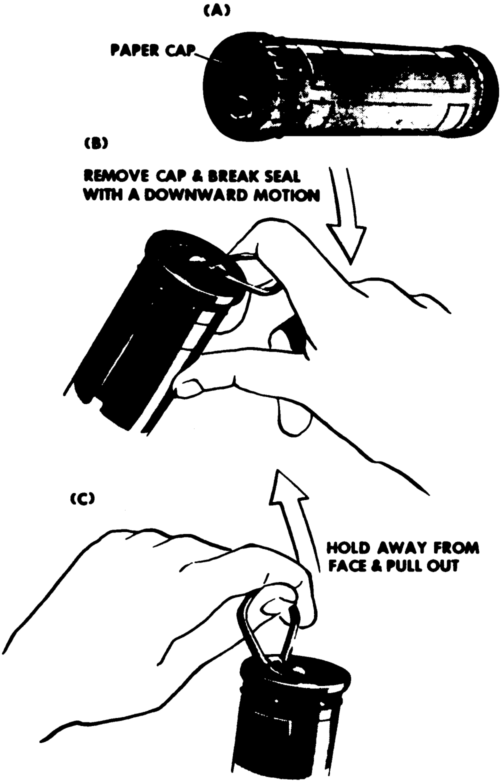


Figure 10–18.—How to ignite a Mk 13 Mod 0 distress signal.

The kit is ordered when the raft is put in commission. When ordering first aid kits, a Bureau of Medicine and Surgery number must be used. The stock number can be found in the Life Rafts and Rescue Equipment section of the *ASO Catalog*. Inside each kit, the directions outline the emergency use of the medicine and equipment.

First aid kits, of a different kind, are also carried in all aircraft. These are contained in a small canvas bag designed with a slide fastener closure and two large curtain type snaps. The snaps are used to secure the kit in some specified available location inside the cockpit or cabin of the aircraft. Similar to first aid kits used in multiplace life rafts, the aircraft kits are furnished with directions for their use. The *Standard First-Aid Training Course*, NavPers 10081 contains detailed instructions for giving first aid to the injured.

RATIONS.—Tablet rations are contained in a pneumatically sealed can which can be opened with the key provided. The rations are not designed to satisfy the pangs of hunger experienced from an empty stomach. The sucrose and malt tablets contain a highly concentrated food value while the vitamin tablets, essential for normal nutrition, supplement the food value in the ration tablets. Each can contains 5 sucrose-citric acid tablets, 10 sucrose-lipid-citric acid tablets, 8 sucrose-malted milk tablets, 2 multivitamin tablets, 2 chewing gum tablets, 1 waterproof bag, and two clips. The chewing gum, when chewed, will stimulate the flow of saliva and consequently retard thirst. Unused tablets can be preserved in the waterproof bag, held closed by the paper clips. One can of rations should be supplied for each man for which the raft is designed to accommodate. They are stowed in the emergency equipment container.

SUNBURN OINTMENT.—One small can of sunburn ointment is supplied with each life raft regardless of size and is stowed in the emergency container. Apply the ointment to all exposed areas of the skin sparingly.

Dimensions, Weights, and Capacities

DIMENSIONS.—Multiplace life rafts are manufactured in accordance with the specific size requirements. (See table 10–1.)

Table 10–1.—Life raft dimensions

Section	Mk 2	Mk 4	Mk 7
Length, feet	7′ 6″ (±2″)	9′ 2″ (±2″)	12′ (±2″).
Width, bow and stern, feet.	4′ (±1″)	5′ (±1″)	5′ 8″ (±1″).

NOTE: Dimensions apply to measurements when the raft is inflated approximately to 1 p. s. i.

WEIGHTS.—Life rafts and equipment are designed not to exceed specific weight requirements. Parachute Riggers are often consulted on the weights of their articles of equipment, especially when an aircraft is being loaded to capacity. While table 10–2 indicates certain weight specifications, it should be kept in mind that unforeseen modifications and directives eliminating or adding to life rafts and their equipment can change their true weights so that they may differ from the figures given in the table. Therefore, the table is presented as a means of establishing a common ground for estimating purposes which under normal conditions will be reasonably accurate.

Table 10–2.—Weights of life rafts and their equipment

	Mk 2	Mk 4	Mk 7
Contractor shipped (including GFE and contractor installed equipment).	47 lbs	61 lbs	76 lbs.
Government installed equipment.	15 lbs	25 lbs	38 lbs.
Total	62 lbs	86 lbs	114 lbs.

CAPACITIES.—The nominal capacity value as shown in table 10–3 is desired in order that the specified CO_2 charges may inflate the rafts to one pound per square inch pressure at a corrected temperature of 70° F. and at a corrected standard atmospheric pressure.

To properly fill the life raft flotation tube, a cylinder containing a proper charge must be used. To determine the weight of a properly charged cylinder, its tare weight (weight of empty cylinder) must be known and should appear stenciled on each cylinder. The tare weight value stenciled on the cylinder should indicate whether or not it includes the valve head. In weighing the cylinder (fitted with cutter type valve and a tare weight stencil which might or might not include the valve) on the scale, a deficiency in its charge can be readily determined. For example, a cylinder weighs

Table 10-3.—Life raft capacities

	Mk 2	Mk 4	Mk 7
Air capacity, cubic feet:			
Minimum	14. 4	26. 4	38. 1
Nominal	14. 8	26. 8	38. 7
Maximum	15. 2	27. 2	39. 9
Internal volume of CO_2 cylinder, cubic inches	96. 0	147. 0	205. 0
Weight of CO_2 charge, pounds	1. 80	3. 25	4. 70
Charging tolerances	±. 02	±. 04	±. 06
Load capacity (pounds)	1, 000	1, 800	2, 500

12 pounds. The tare weight stenciled on its side reads 7 pounds. After removing the valve, the cylinder now weighs 9.50 pounds. The cylinder must contain 2.50 pounds of CO_2 as this is the difference between the indicated tare weight and the actual scale reading. If this is the proper charge (2.50 lbs.) the stenciled weight on the side of the cylinder (7.00 lbs.) is an indication of the cylinder's tare weight without the valve. There are other possibilities, all of which are problematical in nature and which must be examined carefully. Whenever there is any doubt of the charge, expend the gas and reweigh the cylinder and valve. Restencil the cylinder, making certain that the tare weight figure indicates if the weight of the valve is included.

When charging a cylinder, the tare or gross weight of the assembly need not be taken into account, since the weight of the cylinder, charging line (with pressure applied), and other necessary charging fixtures are all "zeroed in" (balanced) on a scale before the CO_2 is admitted to the cylinder. In this case, only the weight of the charge must be known in order to execute the process successfully.

Since a cylinder would be of little value without a valve, some sort of mounting device must be used between the cylinder and valve. Cutter type valves are fitted to disk bodies, the disk bodies being screwed into the necks of the cylinders. Seat type valves do not operate on the punctured disk principle and, therefore, are not mounted on cylinders with a machined body or union containing a disk. Refer to chapter 8 where a number of the different cylinder assemblies are illustrated. While the empty cylinder weight will always include the weight of the valve mounting body, it will not always include the weight of the valve, or actuating head as it is sometimes called. Cylinders fitted with seat type valve need not have their valves removed for recharging purposes; therefore, the tare weight indicated on their sides indicates the weight of the cylinder and valve together.

General characteristics.—Life rafts are designed to withstand a specified maximum internal air pressure of 2.0 p. s. i. (in their flotation tubes) without undue leakage over a 24-hour period. Their seam structure and the security of the seams must be strong enough to maintain the security of the rafts under all specified conditions. The raft inflation systems must work smoothly and positively. Their inflation tubes must conform to specified measurements in order to contain an air or gas capacity sufficient for maintaining flotation under the prescribed loads. The rubberized fabric used in their construction must be strong enough to meet with all tensile strength requirements as directed by specifications. The raft fabric will not become damaged when inflated with CO_2 even after the fabric has been subjected to extreme temperatures for a period of 48 hours. Under these conditions, the rafts must assume their proper form in a reasonable amount of time. The fabric used in raft construction must not become cracked or tacky even when subjected to abusive physical treatment and temperatures. In short, the multiplace life rafts are designed to take punishment under all conditions and treatment in all areas of the globe. The Parachute Rigger, through a series of periodic inspections, preventive maintenance procedures, and minor repair applications, can guarantee a long serviceable life for the rafts in his charge.

Inspection

SCHEDULES.—Life rafts are inspected prior to their being placed in service, every three months thereafter, and at any other time doubt exists about their serviceability. When in storage, they are inspected at least once every six months.

PROCEDURES AND TESTS.—A critical inspection entails a thorough examination of the component parts of a life raft and its associated equipment. To conduct an intelligent raft inspection, one must have a knowledge of its construction, characteristics, and inherent weaknesses in relation to what is expected in performance during the raft's serviceable life. The longer a raft is in service, the more critical the inspection should be, especially in areas involving its ability to sustain prescribed air pressures over the specified testing periods. Certainly, the most important consideration concerns the ability of a pneumatic life raft to inflate quickly and smoothly, and to support a load for long periods after inflation. Once the inspection procedure has proved satisfactorily that the raft will inflate properly and will hold the internal pressure of its buoyant gas, there are other factors of the inspection to be considered. Among them are the secondary phases of the inspection which are the completeness and the condition of the equipment designed for purposes of locomotion, detection, and survival.

Eventually, of course, the seaworthiness of a life raft is no more important than the equipment placed in it for survival, since over long periods one would be ineffectual without the other. However, the first consideration is to provide and guarantee a means of getting and keeping the survivors out of the water. How long they will remain undetected is problematical and admittedly such a situation contains many unknown factors. On the other hand, a critical inspection, not having unknown factors, is designed to guarantee a quick and positive raft inflation, together with the availability of a complete line of effective survival equipment.

When following a procedure that contains a number of steps it is well to read the whole procedure before beginning the individual steps. By doing this it may be possible for you to perform several steps at the same time. By reading the whole procedure you can also get a better idea of the complete task and approach it more intelligently. You can gather tools, materials, and equipment before beginning and not have to interrupt the job to find some vital piece of material.

The following outlines of procedure necessary for a critical inspection:

1. Remove the raft from its container and inflate, using the CO_2 system. Observe its inflating action and the firmness of its form after inflation. If the form of the raft (after a period of 15 minutes and after checking temperature conditions which can affect inflation) lacks the required firmness, it should be deflated immediately and a new charge (conforming to exact weight specifications) be discharged into it. This procedure examines the raft's nominal capacity as explained and illustrated in table 10–3 and figure 10–19. A mercury manometer, more compact than a water manometer and equipped with adaptable fittings, is necessary for the low-pressure test. This test is explained later in this chapter. The hose fitting shown in figure 10–19 (A) is threaded into the opened topping-off valve BEFORE the hose is slipped over its projection.

2. With CO_2 cylinder and raft retaining line (see step number 8) removed, inspect inflation manifold threads for damage. Inspect the cylinder for markings (hydrostatic test date, weights, and others previously explained) and the condition of the cylinder assembly as a unit.

3. Examine the inflation manifold and topping-off valves for leakage by applying a solution of soapy water around their exteriors. Rinse areas thoroughly, and dry.

4. Inspect entire raft for signs of deterioration and wear, paying particular attention to the edges of all seams and reinforcing patches. Any separations of the fabrics must be cleaned and recemented. Observe all fabric areas which might have come in contact with exposed metal parts (when rafts are folded and packed in containers, the fabric should be protected from chafing by the application of felt or cheesecloth padding around the metal components which can rub against surface areas). Excessive chafing action

not only weakens the fabric used in flotation tubes, but removes its rubberized coating, thus, increasing the porosity of the fabric which means there will be leakage in these areas. Remove grease and oil marks, using discretion in relation to the rubbing action required in their removal. Cleaning will be discussed later in the chapter under maintenance.

5. Inspect topping-off valves for damaged threads and burred edges. Since burred edges can cut through chafing gear and eventually cut the raft fabric, such rough edges must be removed from all metal surfaces before the raft can be repacked. After smoothing down a burred area, touch it up with aluminum paint to prevent rust.

6. Inspect the condition of the supply pockets and contents, keeping in mind that one of the pockets is removable. The pocket marked SUPPLIES POCKET AND BAILER, secured to a reinforcing patch, contains two large curtain type fasteners. These fasteners must release their gripping action, and also hold the pocket to the raft properly. After examining the contents of both pockets, reseal (with 1⅝-inch tape) the one cemented to the tube and marked SUPPLY POCKET. (Cementing procedures will be discussed under MAINTENANCE PROCEDURES AND EQUIPMENT USED.)

7. Inspect the security of the lines used to tie pockets, containers, and equipment to the lifeline of the raft. The BITTER ENDS of lines should contain servings; and when such ends are terminated in a knot, they should be served to the standing part of the line. Inspect the condition of the lifeline paying attention to the line supports which are cemented to the tube. Examine the contents of the accessories container observing the condition of each article. For example, an oar must contain enough sections of the proper type in order to be assembled as a whole. Since each section is snapped into place, the pins and springs involved in this action must work smoothly and positively and hold the oar rigidly. The reflecting material cemented to one side of the oar blades must be secure. The welds used in the construction of each oar must be smooth and tight. Each oar section and completely assembled oar must be able

to float in water, and when submerged in any position must rise immediately to the surface.

NOTE: The person engaged in examining articles for their overall condition must develop a keen sense of observation which comes with practice, and also possess a knowledge of the articles being inspected. He must ask himself questions: What is this designed to do? does it have any weaknesses? does it need special attention? and, must other things be protected from it? Some of the questions can be answered by knowledge of the design of the article; while others are answered only by experience and association. Every Parachute Rigger must learn to be an expert inspector because much of his job consists of inspecting duties. No one can outline a pat or absolute routine for inspection that will cover every condition under a multitude of circumstances for each and every item. Checkoff lists are valuable in directing a pattern for inspection and prevent the inspector from overlooking steps, but the list cannot fill in the spaces (unknown quantities of problematical situations and conditions) between the lines. The nature of a guarantee for an inspection is contained solidly in knowledge of the subject at hand and is guided flexibly by cross association and experience.

8. Inspect the life raft retaining line for condition, length, security and condition of the end snap, and for presence of the fabric instruction tag (snapped to retaining line) described previously under Contractor Furnished and Installed Equipment. This must be reattached to the new cylinder later. Examine the sea anchor, its securing line, and the security of the mooring patch.

9. Examine the raft container for proper size and condition. This will involve the fabric (cleanliness, tears, rips, snags, etc.), fasteners (looseness, deformities, smoothness of operation, etc.), seams (stitching security, frayed places, etc.), and markings (clearness and completeness).

10. Inspect the condition and size of the emergency equipment container and its contents, removing the sealing tape which must be resealed later. Examine the container retain-

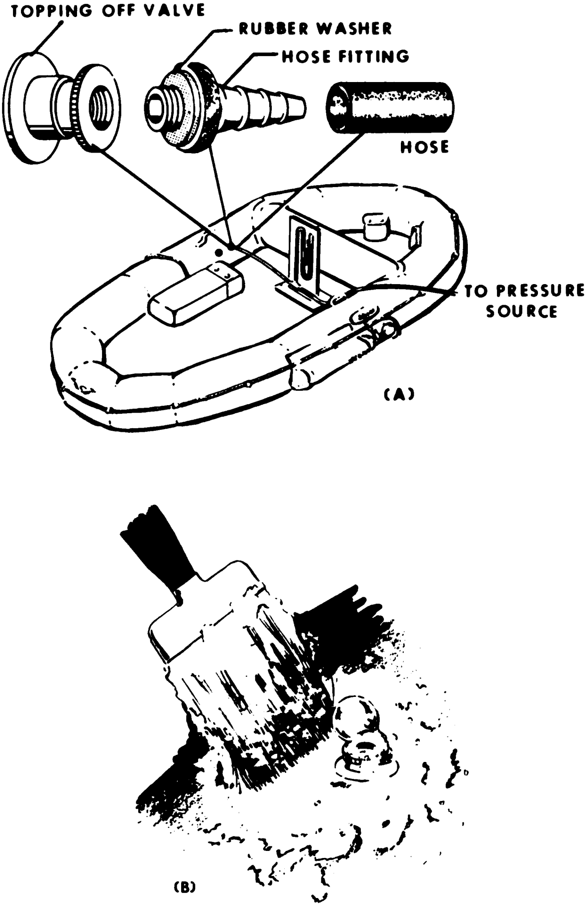


Figure 10–19.—Points of inspection. (A) Manometer check; (B) soap solution application.

ing line and snap for condition. Is the line long enough; or is it too long?

11. After being satisfied that the inspection has been complete and successful up to this point, deflate the raft completely. Deflating procedures are treated under MAINTENANCE PROCEDURES AND EQUIPMENT USE).

12. After the preliminary inflation tests, to check the integrity of the raft and internal bulkheads used to divide

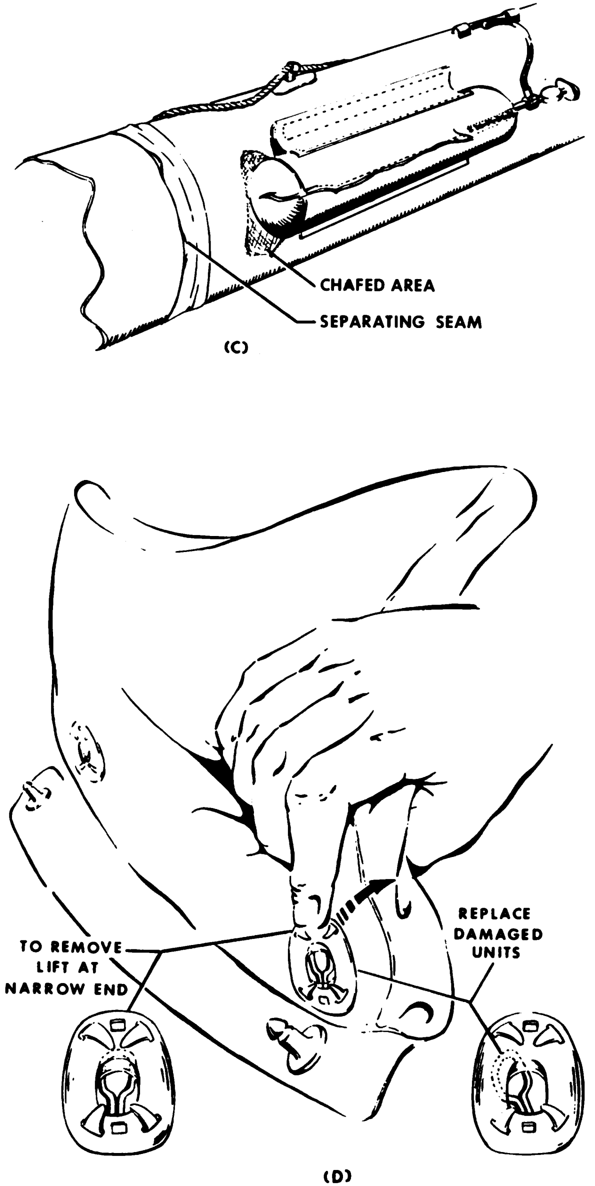
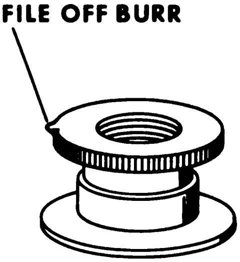


Figure 10-19.—Points of inspection—Continued (C) Seams and chafing; (D) fastener check.



(E)

Figure 10–19.—Point of inspection—Continued
(E) Remove burr.

the flotation tube into two separate sections, the following procedure applies:

a. For accuracy, this test should be made in areas where temperature can be controlled, since gas pressure and pressure readings will be involved. The ideal temperature for making this and most other tests is 70° F. However, all pressure readings must be corrected for temperature where it is not possible to conform to ideal conditions. A change in temperature of 1° F. will cause a corresponding change in pressure of approximately 0.03-inch mercury. Approximate pressure equivalents are given in table 10–4.

Table 10–4.—Pressure equivalents

Pounds per square inch	Inches of mercury
0. 50	1. 02
0. 75	1. 53
1. 0	2. 04
1. 25	2. 55
1. 5	3. 05
2. 0	4. 07
2. 5	5. 09

b. Alternately inflate the raft chambers through the topping-off valves with air instead of using carbon dioxide gas until each compartment of the flotation tube (in turn)

Table 10–5.—Pressures for life raft check

Raft size	Raft component	Initial inflation pressure, p. s. i.	Permissible final pressure, p. s. i.
Mk 2, 4, and 7.	Each tube compartment (test separately).	2. 0	1. 25
	Inflatable seats	1. 0	0. 5
AR–4*	Each tube compartment and top tube (tested separately).	2. 0	1. 25
	Inflatable floor. Test each compartment separately.	1. 0	0. 5
PK–2*		2. 0	1. 50

*The AR–4 pneumatic life boat (sometimes called life raft) and PK–2 pararaft are included in the table so that this information will not have to be repeated later. Compartments are tested separately as a check on the internal bulkheads.

attains the pressure indicated in table 10–5, as measured with a mercury manometer.

c. Adjust the pressure after one hour to allow for temperature and other changes. If, after 24 hours, the pressure, corrected for any difference between temperature at the beginning and end of the 24-hour period, is not less than the amount specified in table 10–5, the raft may be considered sufficiently tight. If, however, after 24 hours the raft shows a final corrected pressure (difference between actual pressure indicated on manometer scale and the affected drop in pressure caused by a cold temperature) of less than the amount permissible shown in table 10–5, the raft must be coated carefully with a soap solution (castile soap and water) to locate the leak. When applying the soap solution, take care not to work up a bubbling condition. Leaks, indicated by the repeated appearance of bubbles, must be repaired as will be discussed under MAINTENANCE PROCEDURES AND EQUIPMENT USED. After patching, the test must be repeated. The raft must be rinsed thoroughly with clear water to completely remove all traces of soap; dry all parts. When inflating life rafts for tests with air under pressure, provisions must be made for extracting oil and moisture from the air line so that the interior of the rafts will be left in a dry condition. When the pressure side of a vacuum cleaner (of adequate capacity) is used, the oil and moisture extraction precautions are not necessary.

Figures 10–19 and 10–20 illustrate some of the problems discussed under the procedures for inspection.

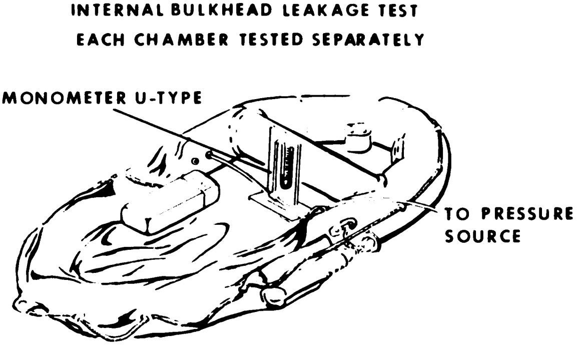

INTERNAL BULKHEAD LEAKAGE TEST
EACH CHAMBER TESTED SEPARATELY
MONOMETER U-TYPE
TO PRESSURE SOURCE

Figure 10–20.—Internal bulkhead check.

Survey of life rafts.—Life rafts can be surveyed under the following conditions:

1. When major repairs are required, such as patching internal bulkheads, replacing a section of porous flotation tube fabric, or opening a flotation tube seam for other reasons, the raft must be surveyed.
2. All multiplace rafts which fail to pass the prescribed inflation test in accordance with the latest Bureau of Aeronautics Directives are surveyed.

Disposition of life rafts.—The disposition of surveyed rafts is as follows:

1. All usable underage fabric and accessories can be retained and used in the repair or modification of serviceable life rafts.
2. Inflation gear, sea anchors, and other equipment and accessories not required for local use in repair or modification of serviceable rafts should be shipped to the nearest

Aviation Supply Depot for stock, listing the items and quantities shipped.

3. Surveyed rafts may be repaired for ground training and/or recreational use. The number of rafts repaired for such purposes is limited by the local activity. Rafts retained under these conditions have the following phrase indelibly stenciled in 1-inch letters on both the raft and raft case: NOT TO BE CARRIED IN AIRCRAFT—FOR GROUND USE ONLY.

MAINTENANCE PROCEDURES AND EQUIPMENT USED

Cement

NATURAL RUBBER CEMENT.—The rubber compound used in the cement is made from the best quality hard Para rubber obtainable. Suitable compounding materials are added, during manufacture of the cement, in sufficient quantities to insure that the resulting cement will have the desired properties necessary for use (maximum results) with NATURAL RUBBERIZED MATERIALS. The cement contains a solvent which will evaporate, leaving a flexible film having suitable tackiness, strength, stretch, adhesion, aging, and working qualities for applications involving life raft repairs. The solvents used are BENZOL, SOLVENT NAPHTHA, or a COMBINATION OF BOTH. Other high-grade solvents may be used provided that they are equally suitable for the purposes, and provided that they are not injurious to the material to which applied.

TYPES AND USE.—Type A natural rubber (self-curing) cement may be a one-part material, or a two-part material consisting of a cement and a separate additive that does not change its characteristics or properties. TYPE B natural rubber (air-drying) cement is a one-part material substance. TYPE B cement was made adaptable for use in life raft repair kits, and was supplied in small quantities for this purpose. However, it is no longer being issued for such use as the cement dries up and jells (under long indefinite storage periods) to the extent where it will be of no use when needed, Rubber cement is intended for use in cementing seams, constructing and attaching patches, fabric, and RUBBER accessories in the manufacture and repair of pneumatic life rafts and other rubberized fabric-constructed objects. TYPE A cement is superior to TYPE B cement and should be used wherever practicable. TYPE B is intended for emergency repairs only. However, in the field, it is not always practical to use the self-curing cement as its curing time (time it takes to dry and hold fabric surfaces together under specified tension requirements), at approximately 75° F., takes 30 days (the curing time directed in specifications).

Where a sufficient number of spare rafts are available to replace those undergoing repairs TYPE A cement should be used in preference to TYPE B. In the case of TYPE A self-curing cement, follow carefully the instructions (marked on the container). The method of mixing, the period of time after mixing during which the cement may be used, and any other directions, all of which are made by the manufacturer, must be followed for successful applications. In the case of TYPE B cement, the general information printed on the container is all that is needed. The specified container markings, besides showing the date of manufacture and the specification number (this positively identifies the right cement for the right job) under which the cement was manufactured and other information, caution the user to REPLACE THE TOP TIGHTLY AFTER USE and to STORE THE CONTAINER IN A COOL STOREROOM. These are important and basic requirements. Hard, stringy, lumpy, or watery cement must not be used. Rubber cement is designed to contain a specified amount of solvent to prevent it from drying out and to make it workable. The indiscriminate addition of too much solvent will destroy its adhesion and stretching qualities. Therefore, follow the manufacturer's recommendations for thinning and mixing cement whenever they differ from standard instructions and practices.

When practical, run tests on the cement stowed in the shop. Using scrap rubberized fabric obtained from surveyed rafts or stores, cement two pieces together measuring about 8 inches long and 6 inches wide. Coat the long edges of the pieces to be joined with cement using a ¾-inch overlap. After the cementing process has been completed (do not exceed four coats, and observe drying times), if the joined pieces can be pulled or picked apart easily by hand, the cement or solvent is defective. This, of course, is a rule-of-thumb testing procedure and is not accurate; however, it will in all probability reveal the use of a weak cement which is the important thing.

Positive identification of the proper rubber cement to use can be found in the *Military Standards Index*, *Navy Department Index*, and in the *ASO Catalog* listed under the appropriate class of material.

Patching

MULTIPLACE LIFE RAFTS.—For small holes, cut a patch of rubberized fabric conforming to Specification F–28, Type O, or Specification AN–F–10, Type C, large enough to extend (scalloped edges) beyond the hole or damaged area for a margin of 1½ to 2 inches. If the tear or cut is of sufficient size to permit entrance of the hands and brush on the inside of the damaged tube, patch the affected area from the inside as well as from the outside. Should the damage be in the form of a cut or tear having no material missing, butt (NOT OVERLAP) one edge of the cut to the other when contacting the patch. To prevent cement from coming in contact with undamaged internal tube surfaces, use an appropriate piece of holland cloth under the damaged areas being coated. This will keep the opposite internal surface from sticking accidently to the repaired area. In some cases, the holland cloth will have to be left in the tube. In any event, care must be exercised to prevent cemented areas, not concerned in the repairs, from coming in contact with undamaged surfaces. To make repair operations easier, suitable smooth topped tables are a necessity.

The patching procedure follows:

1. Place the patch (before scalloping) over the hole and mark off the damaged area, following the lines of the patch.
2. Clean the marked area and the underside of the patch

thoroughly with a bristle brush (medium stiffness) dampened with Stoddard Solvent; allow to dry.

3. Thin a small quantity of cement by adding an equal amount of solvent, and mix well.

4. Brush this THINNED CEMENT into the washed area (the first applications of thinned cement are designed to penetrate the pores of the fabric and thereby build a good base for the final heavier coats), filling the edges of the tear as much as possible. After the first coat is DRY, trim off all ravelings, threads, or twisted edges.

5. Apply one more coat of thinned cement; also, apply TWO coats to the patch. Allow to dry 5 to 15 minutes.

6. Apply two additional coats of REGULAR STRENGTH CEMENT to the damaged surfaces and two to the patch. Allow the third coat on the respective surfaces to dry before applying the fourth.

7. When the last coat (fourth) becomes tacky, apply it to the area. Lay it over the damage and roll it down, being careful not to trap air between the cemented surfaces. The patch must be carefully applied in such a manner that it does not have to be torn off and reset. When using a steel roller, keep the roller flat so that its sharp edges will not cut the fabric. (See fig. 10–21.)

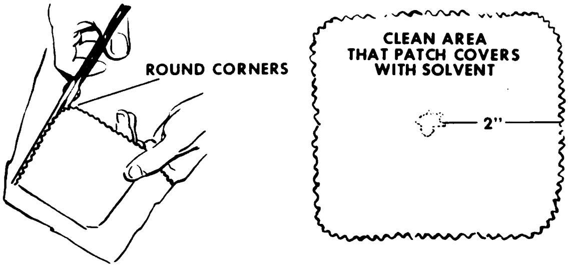


Figure 10–21.—Patching steps.

8. Twenty-four hours after the repair, recheck the raft for leak tightness.

Loose seams, chafing patches, oar patches, and other similar patches can be recemented following the applicable cleaning and patching methods outlined. If, after the tape over a tube seam has been recemented in accordance with instructions, the leak still persists, seeping through the rubberized fabric near the seam, it is an indication that the seam or the tape holding the seam inside the raft is defective. In such case, survey the raft. Loose patches that have been previously applied to repair damages should be removed entirely, and a new patch be applied. All seam and patching repairs affecting the flotation tube of the raft must be checked for tightness by employing air pressure and a mercury manometer to ascertain the effectiveness of the repairs.

CLEANING.—If a general cleaning is necessary, the raft should be cleaned only with a mild soap (castile soap). Do not use coarse scrubbing brushes in the process, as this practice will damage the rubberizing of the fabric, thus causing leakage. All traces of soap must be removed by a thorough rinsing with clear fresh water. After rinsing, dry the raft with a sponge. When dry, dust with talc.

To remove old cement, grease, paint, or other similar stains from the raft, it is permissible to use Stoddard Solvent or some other suitable safety solvent. However, extreme caution must be exercised in their use since they dissolve rubber. When a stain cannot be removed completely, it is better to leave it alone (providing it is not injurious to the fabric) than to continue harsh removal methods. Any stain bears watching, and should be tested for its acid or alkaline content whenever the raft is inspected until the nature of the stain has proven to be noninjurious. WHEN WORKING WITH SOLVENTS, CARRY OUT THE PROCESS IN A WELL-VENTILATED LOCATION.

Equipping and Packing

The types of equipment and the stowage places concerned have been previously discussed in the chapter. However, Parachute Riggers must be on the alert to the possibilities of additions to and deletions from this equipment. Therefore, equip multiplace life rafts in accordance with the latest directives and bulletins. The past use of certain basic survival equipment is a reasonable guide to their continued use, but is no guarantee of their continued use when new and improved equipment and/or .survival methods are developed.

FOLDING THE RAFT.—Multiplace rafts are folded and rolled compactly (in a deflated condition) in order to enclose them in protective carrying cases. In this condition, ready for immediate use, they can be stowed in any convenient location in the fuselage of aircraft. Figures 10–22 to 10–28 illustrate the packing procedure for a Mk 7 life raft. Mk 2 and Mk 4 rafts are packed in the same general manner, and need not be illustrated separately. The following general applications apply to packing multiplace life rafts:

1. Store raft and survival equipment in the pockets and containers provided; seal applicable pockets and containers with tape and cement in accordance with latest bulletins.
2. Attach a fully charged and adequate size CO_2 cylinder to the inflation manifold, making certain that the retaining line is properly connected to the neck of the cylinder. The instruction patch or tag should be attached to the snap at this time. (See fig. 10–22.)

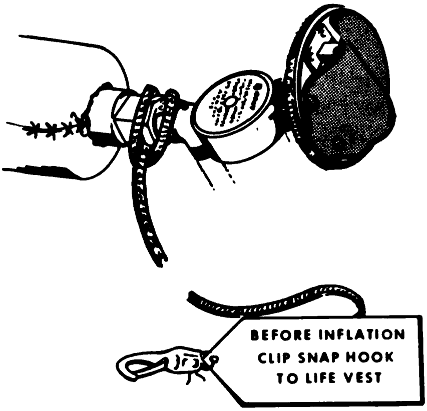


Figure 10–22.—Application of the raft retaining line.

3. Deflate the raft using a vacuum cleaner or some other suitable suction device by applying suction at the topping-off valves of the flotation tube, and where applicable, to the

inflatable seat valves. In order to pack rafts in their respective carrying cases properly, every trace of air or CO_2 must be removed from their pneumatic chambers. Gas trapped in these chambers can prevent folding the rafts compactly. If, in spite of this condition, they can be packed into their carrying cases, the trapped gas will expand at high altitudes. This will pose a dangerous hazard to the construction of the raft and also possibly to the flight efficiency of the aircraft involved. When deflating, it is necessary to keep the opposite internal side of the tube from blocking off the applied suction. Each respective topping-off valve must be closed tightly (by hand) as the gas is exhausted from the tube. This overlapping application prevents the entrance of a small quantity of outside air into the deflated chamber as the valve is being closed. (See fig. 10–23.)

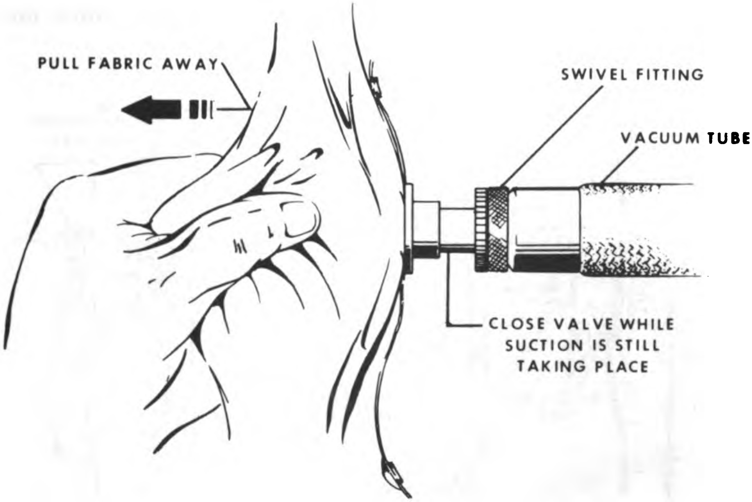


Figure 10–23.—Deflating the raft.

4. Dust the raft with talc, a common soapstone preparation, taking care to apply the talc to ALL SURFACES. The application of talc, acting as a very mild abrasive, is designed to prevent the fabric surfaces from sticking together,

and thereby helps insure a smoother unfolding action when the raft is inflated.

5. Check the RAFT RIGHTING HANDLES for entanglement, the security of the emergency equipment container retaining line to the raft, and the emergency equipment container. Also, check the security of the accessories container retaining line. If not already done, the words, ***Warning:*** LASH ALL EQUIPMENT TO RAFT TO PREVENT LOSS, must be stenciled on the flotation tube, inboard of the top centerline, in one-inch black letters. Check for security and clear the sea anchor and its securing line from the raft. Later, the sea anchor and line will be placed in a position so that it will fall freely into the water when the raft is inflated and unfolding. Apply chafing gear (felt padding and/or cheesecloth) around exposed metal fittings that can damage the raft fabric.

6. Since the raft is folded and rolled around its accessory container (the bulkiest interior item of the raft), aline and

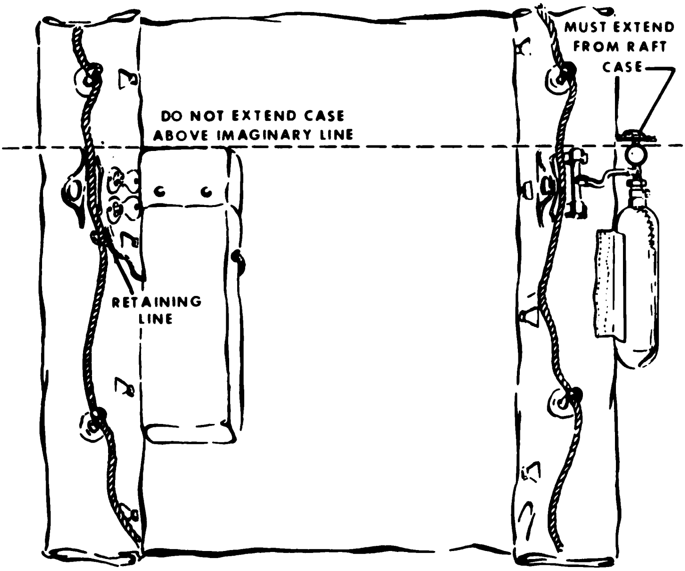

MUST EXTEND FROM RAFT CASE
DO NOT EXTEND CASE ABOVE IMAGINARY LINE
RETAINING LINE

Figure 10–24.—Position of accessory container.

position the container to allow for the proper folding of the raft. (See fig. 10–24.)

7. Lay out the raft carrying case, checking its snap fasteners for condition. Talc the inside of the case.

8. Fold and roll the raft as illustrated in figures 10–25, 10–26, and 10–27, keeping the raft retaining line and emergency equipment container retaining line clear for their final application. The sea anchor retaining line is coiled or faked down on the top fold and the sea anchor is placed on top of or over this line. In this location, it is prepared for immediate action when the raft inflates and ejects the sea anchor into the water. As an aid which may be used to hold the raft closed temporarily before the raft carrying case is placed around the raft and fastened, one or two closing straps can be applied around the body of the raft. Application of these straps prevents the tightly rolled raft from unrolling and making the final closing operation difficult.

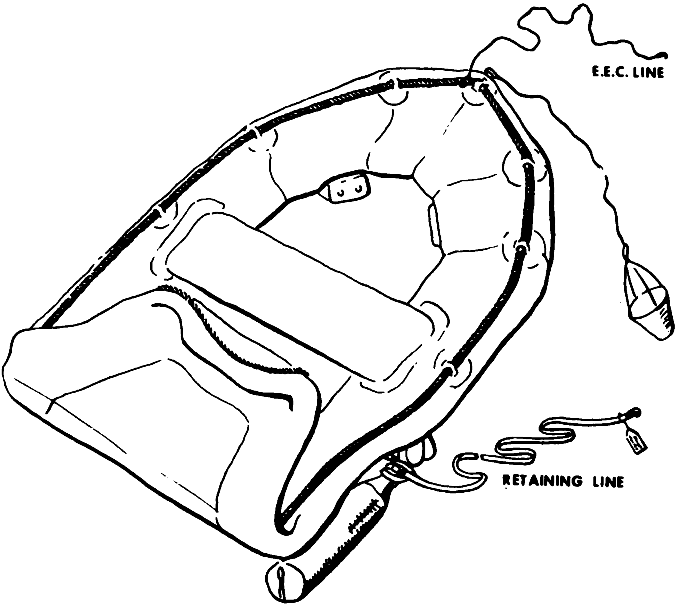


Figure 10–25.—Folding the raft.

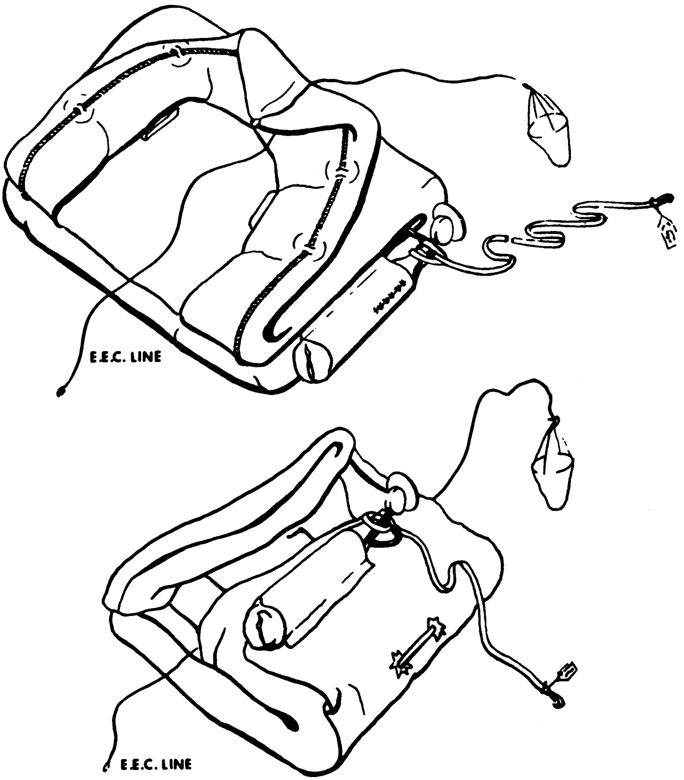


Figure 10–26.—Rolling the raft.

Caution: WHENEVER CLOSING STRAPS ARE USED, THEY MUST BE REMOVED BEFORE THE RAFT CARRYING CASE IS CLOSED COMPLETELY.

9. The top part of the CO_2 cylinder inflation valve or its actuating pull handle must be located accessibly as illustrated in figure 10–28. This figure also illustrates the raft completely packed in its carrying case and attached to the emergency equipment container.

10. Secure a tag, indicating the inspection and packing date, to the outside of the raft carrying case and near the CO_2 pull. The Parachute Rigger responsible for the in-

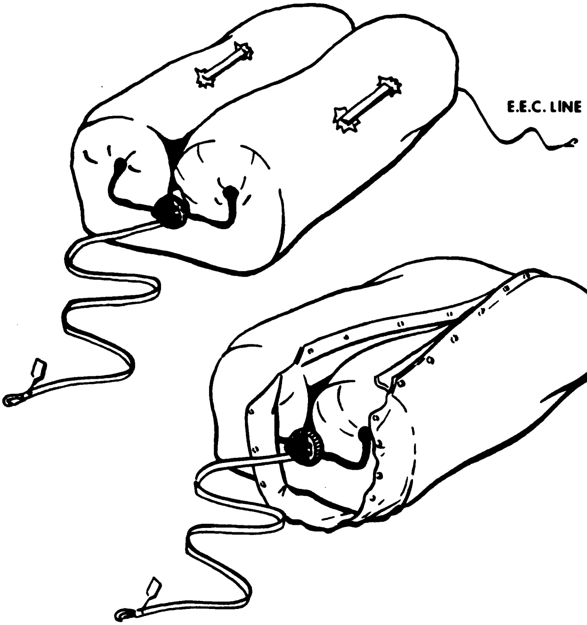


Figure 10–27.—Enclosing the raft in its case.

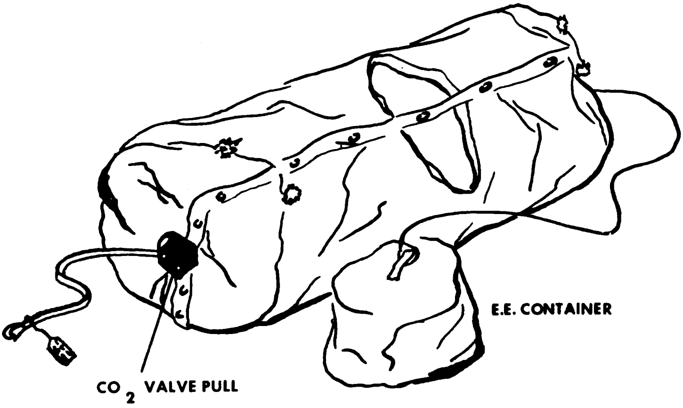


Figure 10–28.—Position of CO_2 cylinder actuating valve pull.

spection, tests, and packing should sign the tag as he would the Parachute Record Card.

STENCILS AND MARKINGS.—For marking rubberized fabric any black, waterfast, vegetable base paint is suitable when using simple field stenciling methods. This would include the use of fiber cut or metal adjustable type stencils and a round, tightly set, bristle brush to apply the paint sparingly. All obliterated or new markings on rafts and their accessories must be restored or be made in accordance with specifications and/or superseding publications. For example, the size or MARK number of a life raft should be stenciled on the raft and on its corresponding carrying case in 2-inch letters and the date of manufacture (month and year) in 1-inch letters. When publications fail to state the exact size lettering to use in a phrase such as, ***Warning:*** LASH ALL EQUIPMENT TO RAFT TO PREVENT LOSS, its significance or value must be considered in relation to the size of the area in which it is to appear. In short, the size of the stenciled letters must be determined by the application of good judgment consistent with the size of the item to be stenciled and the importance of the phrase.

RAFT EJECTION SYSTEMS

Life raft ejection systems are designed to eject their contents automatically and/or manually. Manually operated ejection can be accomplished from a number of points throughout the fuselage and the automatic action is usually actuated initially by an immersion switch, located in a low position in the fuselage. All systems are basically alike and conform to the configuration of the aircraft involved. While some systems are adapted to manual ejection only, others more complicated employ the additional devices which are necessary for automatic ejection.

Two separate raft systems that require a variety of applications will be discussed in this section of the chapter. These systems are broad enough to illustrate different methods of packing rafts (IN and OUT of their carrying cases) in order to conform with the requirements of the systems. Descriptions have been taken from particular aircraft *Handbook—Maintenance Instructions;* therefore, the descriptions and accompanying illustrations cannot be regarded as being universal in nature. They can only show or acquaint the reviewer with the principles involved and the actual mechanisms themselves.

Automatic-Manual System (Combination)

The aircraft shown in figure 10–31 is equipped with one Mk 7 seven-man life raft stowed in a life raft compartment on the right side of the fuselage waist section. In addition, it is equipped with one Mk 4 four-man life raft, stowed on top of the wing beam in the center section of the fuselage. (See fig. 10–31.)

The Mk 7 life raft has been previously described earlier in the chapter. This raft assembly (fig. 10–30) is stowed in the raft compartment on the right side of the waist section. The assembly consists of a fabric carrying case, a Mk 7 life raft, emergency equipment container, and a radio transmitter. The emergency container and radio transmitter are attached to the raft by a 10-foot line. The raft is held in place within its compartment on both the inboard and outboard sides by canvas retainers, and is accessible through a removable panel in the fuselage at the life raft frame. The raft may be released either automatically or manually.

REMOVAL OF MK 7 LIFE RAFT.—The raft is removed from its compartment in the following manner:

1. Disconnect the inflation cylinder cable.
2. Release the inboard canvas retainer holding the raft in place.
3. Lift the raft, emergency container, and the transmitter out of the recess (compartment).
4. Unhook the life raft painter.

MAINTENANCE.—For the proper maintenance of the Mk 7 life raft in conjunction with the releasing mechanism and certain other basic considerations, the following applies:

1. Protect the control cables and fittings against corrosion by keeping them coated with an authorized preservative. (See fig. 10–29.)

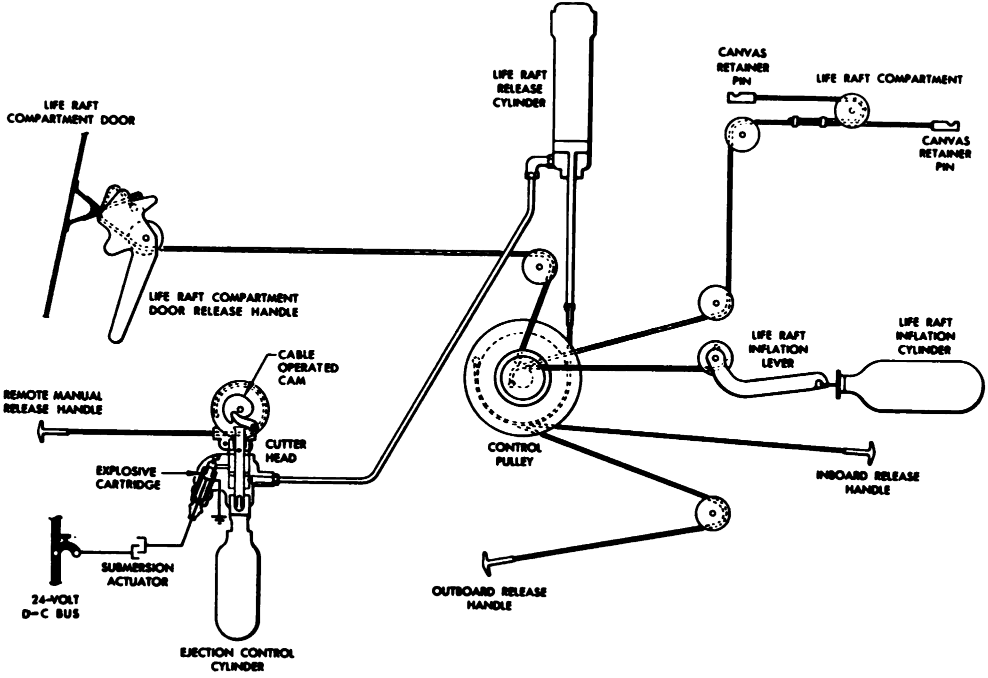


Figure 10–29.—Life raft release mechanism schematic diagram.

2. Keep the release mechanism guard and the control cylinder piston guard in good repair so they will not interfere with the operation of the units.

3. If any parts of the release cable system are damaged or worn, replace them.

4. There can be no faulty insulation, corroded or loose terminals in the wiring to the submersion actuator. The electrical coupling at the control cylinder must not be damaged.

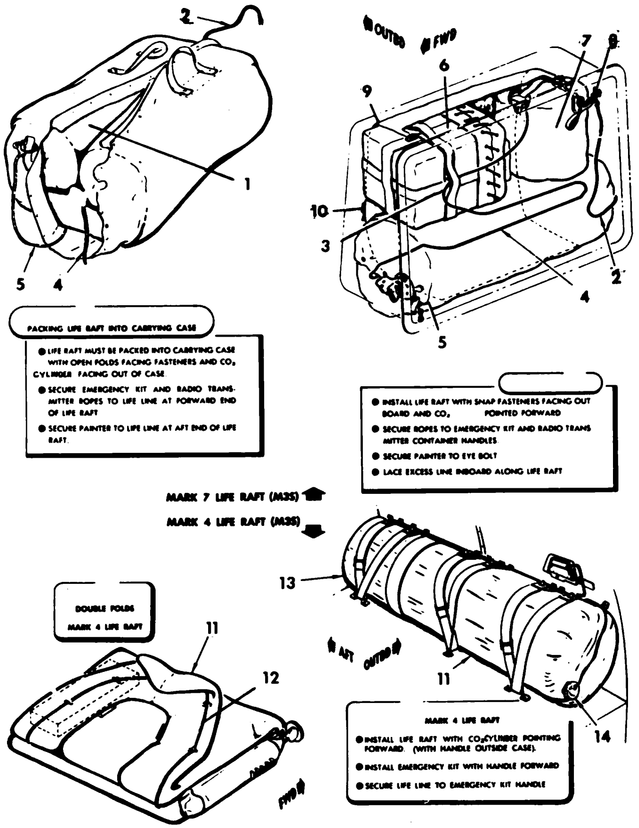
5. The specified charge must be maintained in the life raft inflation cylinder and in the control cylinder.

6. Before overwater flights are undertaken, all major items of the life raft assembly must be checked. (Ordinarily rafts are inspected, tested, and repacked once every three months; however, local conditions and extenuating circumstances can require certain phases of the inspection to be repeated more often.)

PACKING THE MK 7 LIFE RAFT.—When replacing a life raft, always be certain that the life raft is packed in accordance with the instructions, otherwise the raft will not eject properly. The raft must be deflated completely prior to folding, and all folded surfaces must be well powdered with talc. See figure 10–30 for the complete folding and packing procedure.

INSTALLATION OF THE MK 7 LIFE RAFT.—Before attempting to prepare and install the life raft, make certain that it is the type that mounts the inflation cylinder on the end of the folded pack, and that the raft is packed as illustrated in figure 10–30. The outboard canvas retainer (16) must be properly installed, and the straps (17, only one is visible) be adjusted to hold the weight of the raft and equipment away from the door.

Be certain the raft is installed properly in its carrying case, with the emergency equipment container and the compartment with the release cable toward the front, and at the inboard side adjacent to the cutout in the inboard retainer. The snap fasteners on the life raft carrying case must be on the outboard side. If the emergency equipment container and transmitter are not available, install dummy packages



PACKING LIFE RAFT INTO CARRYING CASE

- ● LIFE RAFT MUST BE PACKED INTO CARRYING CASE WITH OPEN FOLDS FACING FASTENERS AND CO_2 CYLINDER FACING OUT OF CASE.
- ● SECURE EMERGENCY KIT AND RADIO TRANSMITTER ROPES TO LIFE LINE AT FORWARD END OF LIFE RAFT
- ● SECURE PAINTER TO LIFE LINE AT AFT END OF LIFE RAFT.

- ● INSTALL LIFE RAFT WITH SNAP FASTENERS FACING OUTBOARD AND CO_2 POINTED FORWARD
- ● SECURE ROPES TO EMERGENCY KIT AND RADIO TRANSMITTER CONTAINER HANDLES.
- ● SECURE PAINTER TO EYE BOLT
- ● LACE EXCESS LINE INBOARD ALONG LIFE RAFT

MARK 4 LIFE RAFT

- ● INSTALL LIFE RAFT WITH CO_2 CYLINDER POINTING FORWARD. (WITH HANDLE OUTSIDE CASE).
- ● INSTALL EMERGENCY KIT WITH HANDLE FORWARD
- ● SECURE LIFE LINE TO EMERGENCY KIT HANDLE

Figure 10–30.—Life raft packing procedure.

1. Mk 7 life raft.
2. Painter. (Approx. 25 feet long.)
3. Line passed through transmitter CSE strap.
4. Emergency equipment container line.
5. Raft retainer line.
6. Radio transmitter.
7. Emergency kit container.
8. Eyebolt.
9. Outboard canvas retainer.
10. Adjusting strap.
11. Mk 4 life raft.
12. Lifeline.
13. Emergency kit container.
14. CO_2 cylinder pull.

of the same weight and size. This will insure the proper predetermined action necessary to operate the assembly.

Hook the painter of the life raft to the eye on the aft side of the life raft recess (fig. 10–30). The PAINTER is constructed from 200-pound test line and is fitted with snaps on both ends. DO NOT CONFUSE THE PAINTER WITH THE OTHER REGULAR LINES. Stow (tuck) excess lengths of the painter (25 feet long), emergency equipment line, and raft retaining line (1-inch wide webbing) inside the raft carrying case.

Attach the inflation cylinder release cable to the actuating lever and safety it with the clip or spring provided.

MK 7 LIFE RAFT HATCH.—The life raft hatch is located on the right side of the fuselage. The door, which conforms to the contour of the fuselage, can be jettisoned. Canvas retainers hold the life raft assembly in place in the life raft frame container. When any of the life raft releases are pulled, or when the submersion actuator is submerged in salt water, the door is released, the outboard canvas retainer is released, the life raft inflates, and pushes itself out of the life raft container. The inboard canvas retainer may then be released by unzipping it and the cutout may be used for emergency escape.

RELEASE OF MK 7 LIFE RAFT.—This raft may be released electrically (automatically) by a salt water submersion actuator located, in this case, on the right side of the nosewheel well. The actuator contains interleaved plates, alternate plates being connected to the two terminals of the actuator, with spaces between the plates so that an open circuit is normally maintained. In the event that water enters the spaces between the plates, the circuit to the control head on the life raft inflation cylinder is completed, firing a cartridge in the control head, and causing the cylinder to be opened and the raft inflated. The actuator is connected directly to the battery terminal of the battery relay, and thus is HOT at all times that batteries are installed in the airplane.

Manual release handles are provided both inside and outside the airplane. (See fig. 10–32.) Exterior handles for manual release are located on top of the fuselage just aft of the navigator's escape hatch, and at the forward edge of the life raft cutout. Interior handles for manual release are located at the forward edge of the life raft cutout, on the upper right side of the navigator-bombardier's compartment, on the upper right side of the radar operator's compartment, and above and to the right of the pilot's seat on the bulkhead.

When the Mk 7 raft is released from any station other than

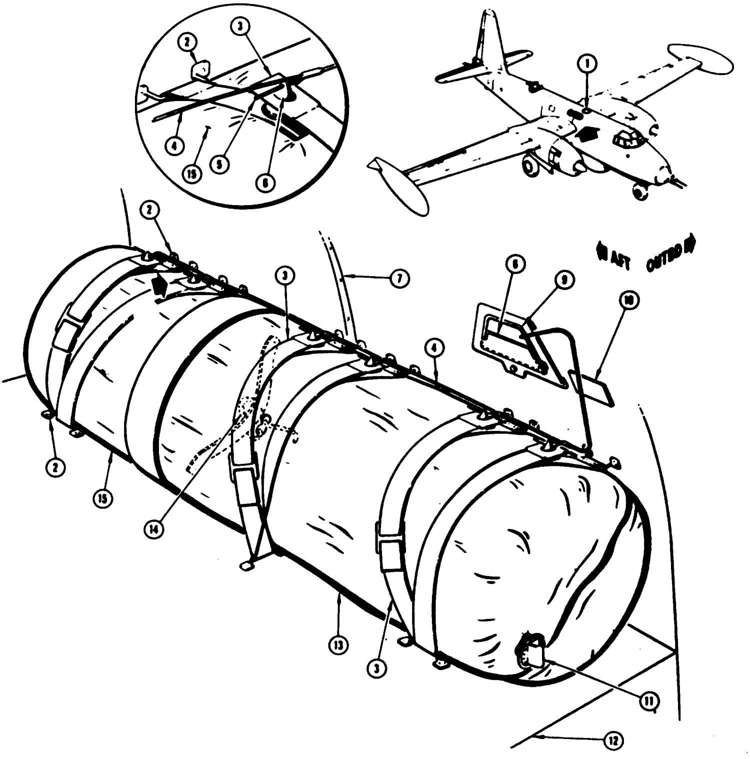


Figure 10–31.—Mk 4 life raft installation.

1. Navigator's astro-hatch.
2. Footman loop (typical).
3. Strap assembly.
4. Release cable assembly.
5. Pin.
6. Cone.
7. Insulation seam.
8. Release handle pocket.
9. Release handle.
10. Nameplate.
11. CO_2 cylinder.
12. Front wing beam.
13. Mk 4 life raft.
14. Lifeline connection, emergency equipment container.
15. Mk 4 emergency equipment container.

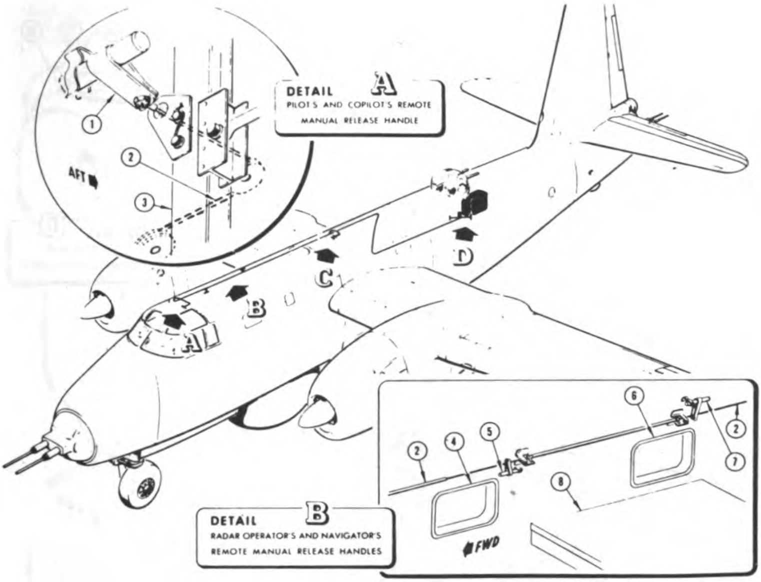
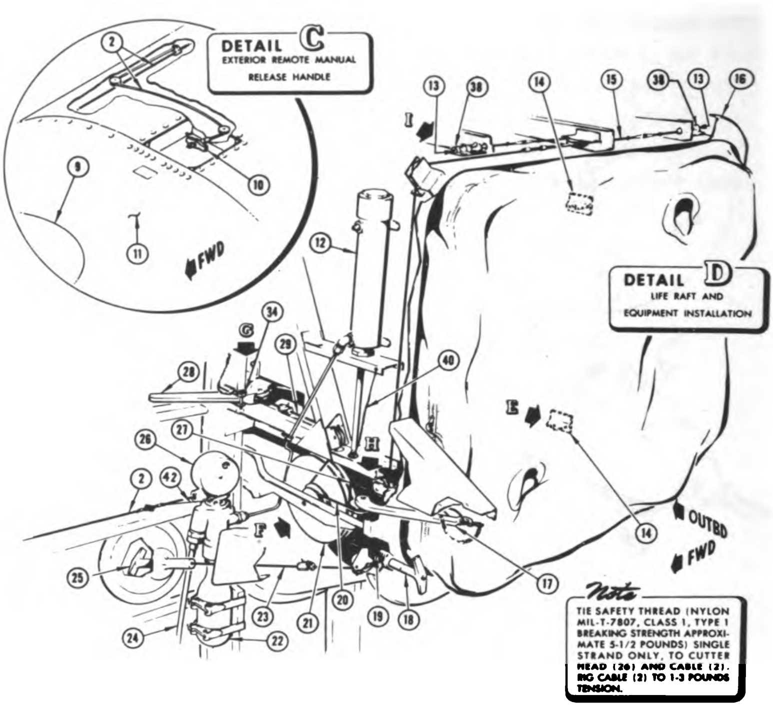

DETAIL A
PILOT'S AND COPILOT'S REMOTE MANUAL RELEASE HANDLE
AFT
1
2
3
A
B
C
D
DETAIL B
RADAR OPERATOR'S AND NAVIGATOR'S REMOTE MANUAL RELEASE HANDLES
FWD
2
4
5
6
2
7
8

Figure 10–32.—Life raft release mechanism rigging diagram.

Nomenclature for figures 10–32 through 10–35.

1. Flight station manual release handle.
2. Remote manual release cable.
3. Station 186 bulkhead.
4. Radar operator's window.
5. Radar operator's manual release handle.
6. Navigator's window.
7. Navigator's manual release handle.
8. Navigator's table.
9. Navigator's astro-hatch.
10. Exterior release handle.
11. Top fuselage panel.
12. Life raft release cylinder.
13. Outboard retainer pins.
14. Door aft retainer yoke.
15. Outboard retainer pin release cable.
16. Life raft compartment frame.
17. Life raft inflation lever.
18. Inboard release handle.
19. Inboard manual release cable.
20. Inflation lever cable.
21. Control pulley.
22. Control cylinder.
23. Outboard manual release cable.
24. Electrical cable and cartridge receptacle.
25. Outboard release handle.
26. Control cylinder cutter head.
27. Release cylinder cable.
28. Door release handle.
29. Door release cable.
30. Mounting plate.
31. Shims.
32. Serrated mounting plate.
33. Door.
34. Door release handle lockpin.
35. Door release cam.
36. Door forward retainer.
37. Inflation lever pulley.
38. Pin guide.
39. Outboard retainer yoke.
40. Safety wire.
41. Strap.
42. Safety thread.



Note

TIE SAFETY THREAD (NYLON MIL-T-7807, CLASS 1, TYPE 1 BREAKING STRENGTH APPROXIMATE 5-1/2 POUNDS) SINGLE STRAND ONLY, TO CUTTER HEAD (26) AND CABLE (2). RIG CABLE (2) TO 1-3 POUNDS TENSION.

Figure 10–33.—Life raft release mechanism rigging diagram—Continued.

the inside or outside releases at the life raft station, a small control cylinder (22, fig. 10–33) mounted just forward of the raft compartment actuates a release piston inside the cylinder (12, fig. 10–33) to which a cable is attached. The outside door panel is then unlatched and ejected, and the outboard retainer (39, fig. 10–35) is released. The carbon dioxide inflation cylinder operates and causes the raft to inflate and be pushed overboard. A raft release handle (18, fig. 10–33) and a door release lever (28, fig. 10–33) are provided next to the life raft retaining frame (16, fig. 10–33). The lower handle, when pulled bypasses the control cylinder and operates by direct mechanical linkage to unlock the outside door panel, release the outboard canvas retainer, and inflate the life raft. The upper lever, when pulled, releases the forward latch on the door panel, allowing it to fall clear

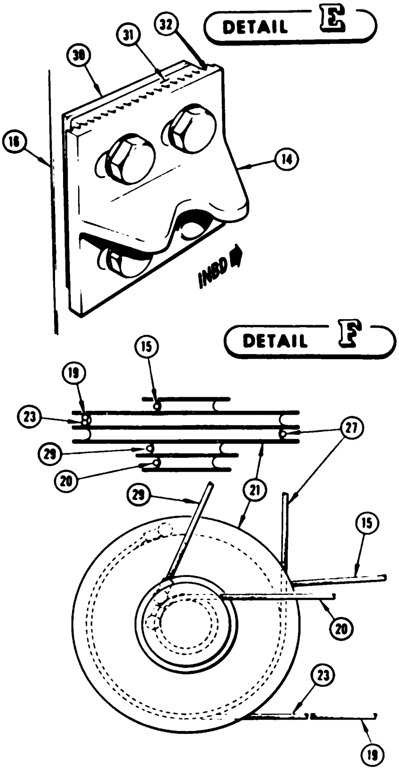


Figure 10–34.—Life raft release mechansim rigging diagram—Continued.

while the outboard retainer is still holding the raft in place uninflated. After the airplane has been ditched, the raft may be released from any of the previously mentioned stations, or by means of the submersion actuator.

RIGGING MK 7 LIFE RAFT RELEASE MECHANISM.—The successful ejection operation depends on the following procedures for this particular aircraft as it does for other similar mechanisms related to other aircraft:

1. Install the removable door panel (33, fig. 10–35) by fitting the aft end of the door into the yokes (14, fig. 10–33) on the frame (16, fig. 10–33), then engage the forward retainer (36, fig. 10–35) with the cam (35, fig. 10–35) and the

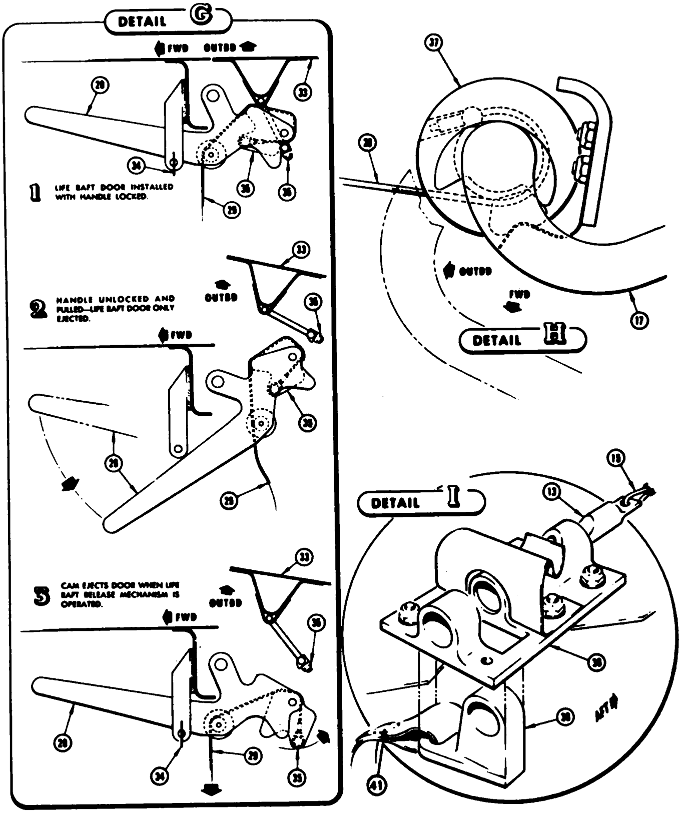

DETAIL G
FWD
OUTBD
1 LIFE RAFT DOOR INSTALLED WITH HANDLE LOCKED.
2 HANDLE UNLOCKED AND PULLED—LIFE RAFT DOOR ONLY EJECTED.
3 CAM EJECTS DOOR WHEN LIFE RAFT RELEASE MECHANISM IS OPERATED.
28
33
34
35
36
29
37
17
DETAIL H
DETAIL I
19
13
39
38
41

Figure 10–35.—Life raft release mechanism rigging diagram—Continued.

door release handle (28, fig. 10–35). If necessary, adjust the position of the yokes (14, fig. 10–34) by means of the serrated mounting plate (32, fig. 10–34) and shims (31, fig. 10–34) to obtain a proper fit of the door. Adjustment of the front end of the door may be made with the nuts which secure the retainer (36, fig. 10–35).

2. Install the door-release-lever lockpin (34, figs. 10–33 and 10–35).

3. Secure the outboard canvas retainer in place by engaging the two yokes (39, fig. 10–35) with pins (13, figs. 10–33 and 10–35) at the top of the raft compartments. Seat the

pins fully in the guides (38, fig. 10–35) so the pin retaining springs are engaged.

4. Adjust straps (41, fig. 10–35) on canvas retainer so that they will hold the raft and equipment approximately one inch from the door panel.

5. Place the raft inflation lever (17, fig. 10–33) in its cocked position (pointing inboard). Rotate the inflation lever pulley (37, fig. 10–35) counterclockwise until the pulley spring engages the detent on the pulley. The pulley detent must be bottomed in the spring.

6. Push the piston rod up into the cylinder (12, fig. 10–33). Install safety wire from the piston rod end to the cylinder support channel to hold the piston in this position.

7. Tighten the turnbuckles in cables (15, 23, and 29, fig. 10–34) to remove all slack from the cables.

8. Remove slack from cable (19, fig. 10–34) by adding spacers as necessary under the inboard release handle guide.

9. Check action of the release cylinder operation as follows:

a. Pull release handle.

b. Move piston rod of release cylinder (12, fig. 10–33) to full UP position.

c. Manually turn control pulley (21, fig. 10–34) counterclockwise (facing aft), the full amount permitted by the first cable which becomes taut. Release cylinder cable (27, fig. 10–34) must be slack in this position. Before proceeding, check all cables to be certain they are securely attached and are properly engaged in the grooves of the pulleys. Use a mirror to inspect cables hidden by structural members. Failure of the release mechanism may result if the cables do not seat in the pulley grooves.

9. Make certain that a serviceable control cylinder (22, fig. 10–33) and cutter head (26, fig. 10–33) are installed and connected.

INSTALLATION OF CONTROL CYLINDER.—A similar installation has been treated in chapter 9, concerning carbon dioxide systems.

INSTALLATION OF THE MK 4 LIFE RAFT.—This assembly, in relation to this particular aircraft, was designed to be rigged for a quick manual release inside the fuselage. It is carried by hand through the navigator's astro-hatch escape hatch, and is inflated manually outside the airplane.

The Mk 4 raft and its emergency equipment container are stowed in a horizontal position as shown in figure 10–31. One end of the emergency equipment container line is securely fastened to the raft. Figure 10–31 illustrates the release mechanism, and figure 10–30 indicates the recommended folds.

Manual System

The manual life raft ejection system is not equipped with an electric submersion switch or actuating control cylinder. It is operated by a pull which transmits the action directly to the inflation cylinder of the raft and the releasing pins of

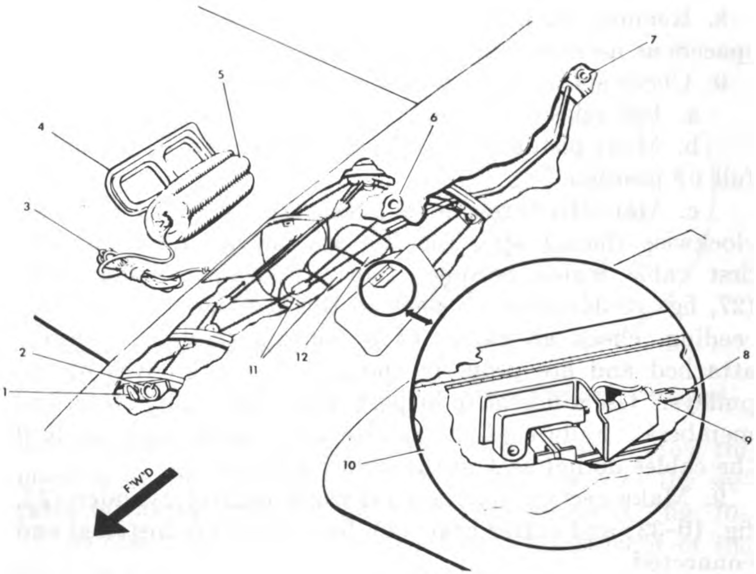


Figure 10–36.—Manual ejection system.

1. Interior release handle.
2. Forward interior release handle.
3. Painter.
4. Life raft door.
5. Life raft (Mk 7).
6. Exterior release ring.
7. Aft interior release ring.
8. Door release cable.
9. Door locking pin.
10. Door.
11. Emergency equipment kits.
12. Radio transmitter.

a jettisonable door panel. Some of the manual systems are designed in such a way that the life raft is packed or folded into the recess frame WITHOUT ITS CARRYING CASE. When this is the case, care must be exercised not to pinch the raft fabric in the releasing mechanisms as the door panel is being locked in place. Figure 10–36 illustrates a manual system and the method of packing a life raft for application in this system.

PARARAFT

The 1-man raft was designed for use as its designation Pararaft Kit (PK–2) implies—parachute raft kit. The number 2 in the symbol indicates that this is the second model. When new and improved pararafts are designed, the model number will change—perhaps the entire designating symbol. Chapter 4 of *PR 3 & 2*, volume 1, NavPers 10358, discussed the methods of rigging the pararaft to parachutes; and therefore, need not be repeated here. This section of the chapter will be directed to describing the PK–2 and its equipment. Procedures that involve inspection and maintenance problems will be described also. Where procedures parallel those already outlined for multiplace rafts, they will not be repeated; hence, this section may appear brief.

Construction

GENERAL.—The body of the raft consists of an encircling buoyant tube tailored to form the shape shown in figure 10–37. The flotation tube is made in one continuous (single) chamber HAVING NO INTERNAL BULKHEADS as multiplace rafts do. The fabric bottom is applied with a sufficient amount of slackness to prevent distortion of the flotation tube when the raft is inflated.

SEAMS.—All laps used in the construction of the flotation tube are ⅝ inch wide, covered inside and out with TYPE F TAPE, ¾ inch wide. (For accurate identification purposes, necessary to the application of the proper material, specification numbers will have to be referenced.) The construction and quality characteristics of type F tape are described in specification AN–F–10. Fabric used in the construction of the flotation tube is known as TYPE H, and is also described in specification AN–F–10.

CYLINDER CARRIER.—One cylinder carrier, 2 inches in diameter, is applied to the raft in the position shown in figure 10–37.

ORAL INFLATION TUBE AND VALVE.—The oral inflation valve closes automatically by spring pressure when it is not held open. It can be locked shut by turning the mouthpiece in a clockwise direction. The tube (approximately ⅜-inch I. D.) is cemented to the valve at one end and at the other it is equipped with a molded flange which is cemented to the flotation tube.

ORAL INFLATION VALVE POCKET.—The pocket is designed to hold the valve as shown in figure 10–37.

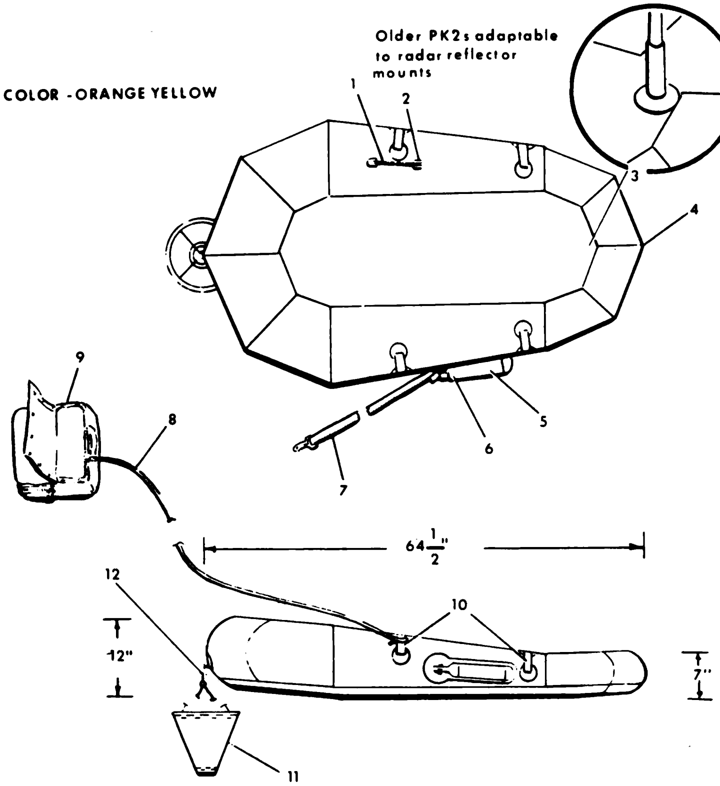
BOARDING STRAPS.—Four handles or straps are provided as aids for boarding the life raft.

INFLATION SYSTEM.—The tube is inflated with a CO_2 charge weighing 0.5 pound. Figure 10–37 illustrates how the cylinder valve is mounted on the inlet check valve of the raft.

SEA ANCHOR.—The sea anchor is tied to the raft mooring line (type 3 nylon cord) with a bowline knot, the other end of which is tied to the sea anchor mooring patch with a square knot. The loose ends of both knots are served with nylon thread to prevent them from untieing. Before assembly, the ends of all nylon cordage are heat fused to prevent fraying.

SECURING LINE.—This line is used to secure the raft to its carrying case and equipment. The 5-foot length of nylon cord is secured by a square knot to the raft sea anchor patch and the other end is also tied with a square knot through the grommet in the raft case. The free ends of the knots are bound or sewed with type B nylon thread.

WEBBING LANYARD.—A nylon webbing lanyard 1 inch wide and 3 feet long is provided to secure the raft to the user. One end of the webbing is equipped with a snap hook (1⅛-inch size). The other end is secured to the CO_2 cylinder neck by means of a loop formed at the end of the webbing, encircling the cylinder neck.



Dimensions taken when raft is inflated to 1 P.S.I.

Volume 4.25 cubic feet ± .05

Figure 10-37.—PK-2 pararaft.

1. **Oral inflation tube valve.**
2. **Valve pocket.**
3. **Radar reflector mount.**
4. **Stern.**
5. **Cylinder carrier.**
6. **Cylinder.**
7. **Retaining webbing.**
8. **Securing line.**
9. **Raft case.**
10. **Handles.**
11. **Sea anchor.**
12. **Mooring sea line.**

Instructions and markings.—The following instructions relative to oral inflation of the life raft are painted in ¼-inch black letters on a white rubber patch adjacent to the oral inflation valve: To Increase Pressure: Push down valve mouthpiece and immediately blow through inlet.

Each raft is durably marked at the large end in black stencil ink with the following:

PARARAFT—MODEL PK-2	(Letters 1″ high)
BUAER SPEC 23 K3	(Letters ½″ high)
NAME OF MANUFACTURER	(Letters ½″ high)
CONTRACT NO.	(Letters ½″ high)
DATE OF MANUFACTURE	(Letters ½″ high)

Weather shield.—One weather shield (nonspecular blue on the outside and red on the inside) is cemented to the raft as shown in figure 10–38.

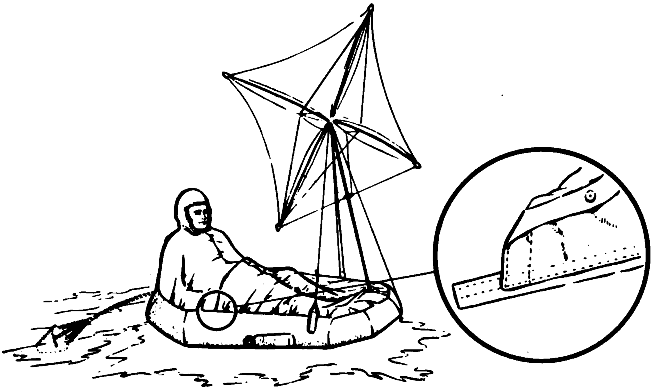


Figure 10–38.—PK-2 weather shield.

Raft case.—The fabric used in the construction of the raft case consists of 2-ply ripstop nylon fabric coated with a crude rubber compound between the plies. The color of the case is the same as the raft.

The size of the case and its general features are shown in figure 10–39. Each case is marked with black paint in ½-inch letters on the side opposite to the snap fasteners. The marking indicates the model number and specification.

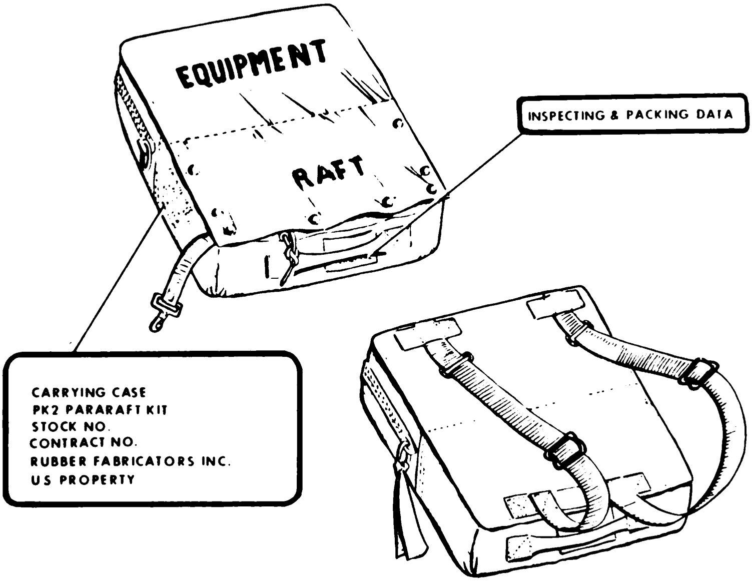


Figure 10–39.—PK–2 raft case.

Inspection card.—A filing card (3 x 5 inches) printed with the following information will suffice: Date (date of inspection and packing), Raft (raft number locally assigned), Equipment (condition and completeness check), and Signature of Parachute Rigger responsible). In addition, each card should contain information relative to the model number, specification number, and designation numbers of the publications directing modifications of the equipment.

Equipment

The equipment described previously under multiplace life rafts is also used in the pararaft kit.

Contractor furnished and installed equipment.—The following equipment is installed in the equipment section of the pararaft kit case: A poncho, water storage bag, and nylon line.

Government furnished, contractor installed equipment.—The following equipment is installed in the equipment section of the pararaft kit case with the other items: A DESALTING KIT, SOLAR STILL, SIGNALING MIRROR, TWO DYE MARKERS, AND TWO DISTRESS SIGNALS (MK 13 MOD 0).

GOVERNMENT FURNISHED AND INSTALLED EQUIPMENT.—A radar reflector (MX–138A/A) adaptable to the pararaft assembly is installed in the equipment section of the raft case. This reflector is similar to the one used in larger rafts; only smaller. A copy of the signaling code (NavAer 00–25–513) is installed in the raft case inspection card pocket, along with the inspection card. To enclose the entire pararaft kit assembly, and to make it adaptable for rigging to parachutes, a pararaft kit container is provided with each pararaft case. In spite of the fact that they both contain something, do not confuse the pararaft kit container and the pararaft case. The kit container contains the case, containing the equipment and the raft. Each container is

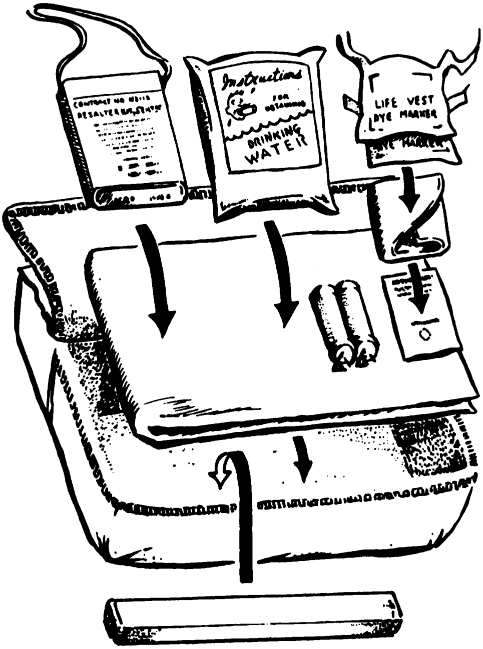


Figure 10–40.—Stowage arrangement of pararaft equipment.

marked in black paint with letters 1-inch high: PARARAFT KIT CONTAINER FOR USE WITH MODEL PK–2 PARARAFT KIT. Figure 10–40 illustrates the stowage arrangement of the contents in the equipment section of the case which are enclosed by a cover and slide fastener. Also shown in the figure is a kit container. The weight of the entire pararaft assembly, including the container, is approximately 19 pounds.

Inspection

SCHEDULE.—Pararaft kits received from supply departments must be inspected prior to placement in service and every three months thereafter while they are in service. Since the kits are sat on (except when rigged to chest type parachutes), they very often need closer attention because of the weight imposed upon them. The individual's weight causes trouble in the form of chafed and badly damaged materials, bent objects, and an overall impacted condition. Every time the parachutes containing pararaft kits are repacked, inspect and rearrange the equipment, keeping the weight factors in mind. In addition to the trouble caused by the applied weight, another consideration is also important. This concerns flatness and smoothness of the entire assembly. A rough or shifted packed condition causes discomfort and fatigue to those who sit on the kits, even though they are separated by a cushion containing a metal pan. When the raft kits are being used every day, inspect the condition of the pararaft where the cylinder is liable to chafe the raft fabric. Chafing gear sometimes shifts or is worn through when subjected to hard usage. Also examine the inlet valve where it joins the tube for cracks or signs of breaking away. This inspection does not require the removal of the raft from its case—only the opening of the front section.

PROCEDURE.—The same principles of inspecting and testing apply to the pararaft as they do to the larger rafts. Where there are considerable differences in their construction, certain steps may be eliminated or added as necessary. For example, pararafts are not constructed with internal separating bulkheads. In view of this, the applicable test previously discussed under multiplace rafts need not be made. As another example, the pararaft is constructed with only one oral inflation tube (one tube for only one chamber). A multiplace raft is fitted with topping-off valves instead, but these valves serve the same purpose as the oral inflation tube of the pararaft. Therefore, the same general considerations given the topping-off valves should be applied to the oral inflation tube; both type valves serve a chamber (through a threaded action); both types are enclosed in chafing gear; and although the exposed end of the oral inflation type valve has no rough edges, it is kept in a supporting pocket. These are some of the differences, but anyone can understand that it will take many practice inspections before all the major, and especially

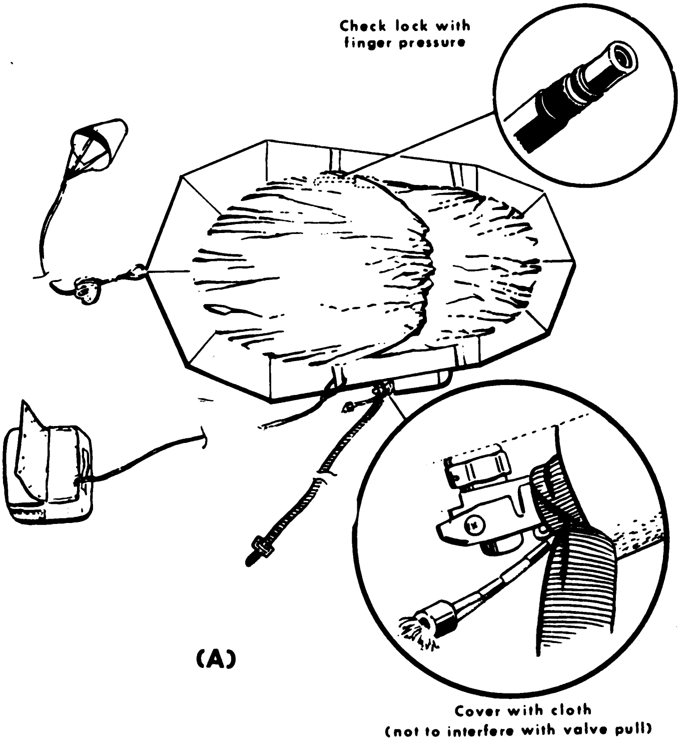


Figure 10-41.—PK-2 packing steps..

the minor seemingly insignificant differences, can be recognized immediately.

Packing

Figure 10–41 illustrates the packing steps necessary for enclosing the pararaft in its section of the case. Each item in the equipment side of the case should be secured in train to prevent loss. The looped end of the webbing lanyard, attached to the cylinder neck, must not interfere with the action

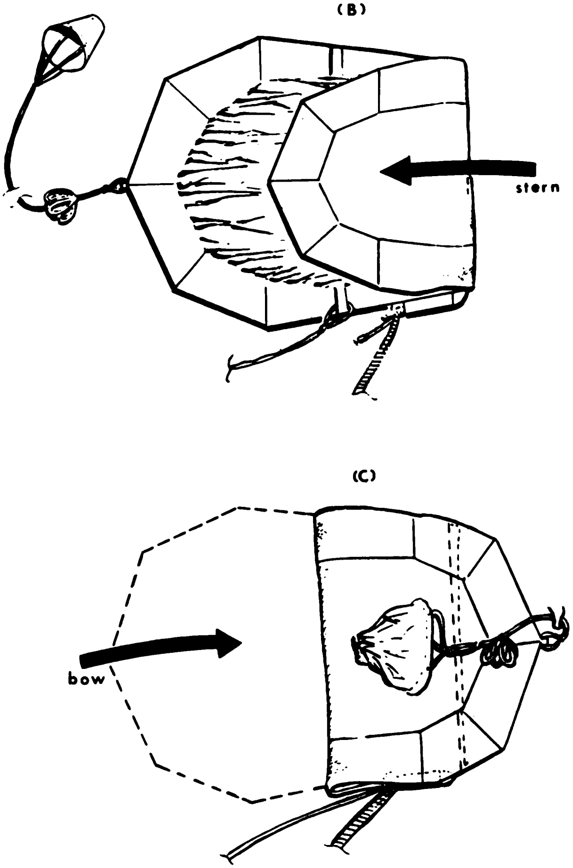


Figure 10–41.—PK-2 packing steps—Continued.

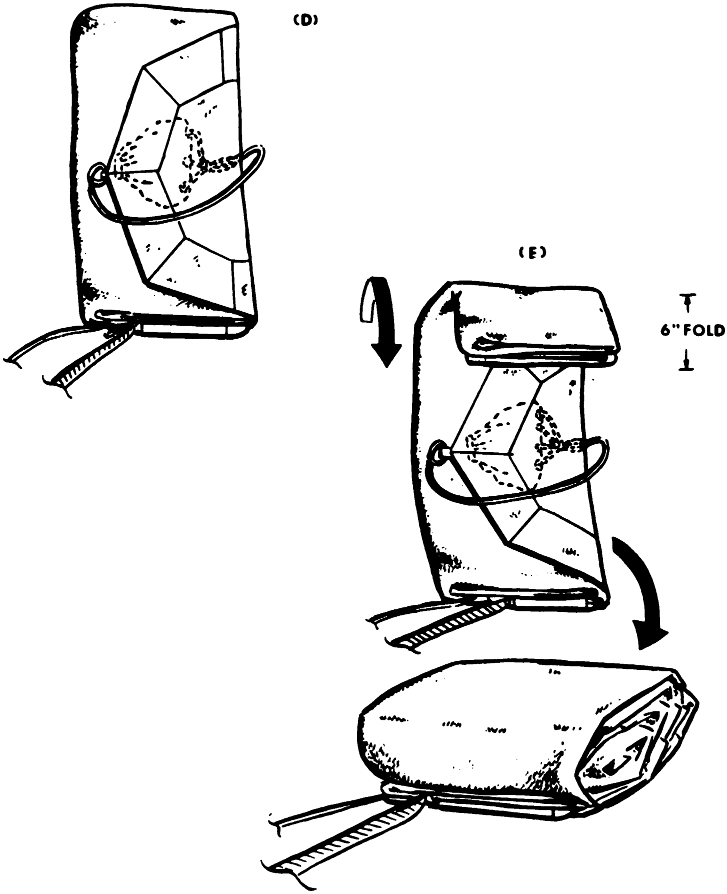


Figure 10–41.—PK–2 packing steps—Continued.

of the valve pull. The valve pull-toggle must be placed in an accessible position—ready for action. After packing, sign the card.

Maintenance

The same principles of maintenance apply to pararafts as they do to the larger rafts. However, since the pararaft is constructed of lighter weight rubberized material, TYPE H

(F)

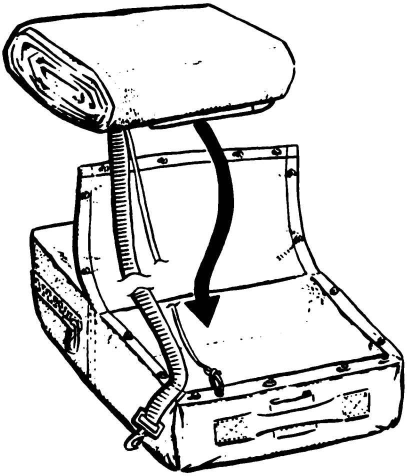


Figure 10–41.—PK–2 packing steps—Continued.

fabric is recommended for patching repairs. Allow a 1½-inch margin (instead of 1½ to 2 inches) beyond the hole or damaged area when cutting a patch. Defective seams other than flotation tube seams, the bottom, and the attachment of the bottom to the tube are repaired by cementing as described previously under multiplace life rafts, using 1½-inch (TYPE E) tape.

Life Rafts—12- and 20-man

These mammoth size pneumatic life rafts have been designed to accommodate the crew and passengers of large passenger and cargo carrying multiengine aircraft used by Navy Transport Squadrons. While the 12-man raft resembles the Mk 7 and/or AR–4 life rafts, the 20-man raft is distinctly different in shape, resembling a large circular doughnut. Both types are constructed of lighter weight fabric (nylon) than the heavier stronger material used in the smaller multiplace rafts. A protective canopy is furnished with the large rafts to shield suvivors from the sun, wind, and spray of the sea. The canopy is reversible; its outer surface is neon red, and the inner surface is blue so that it can be used for camouflage. Both rafts have two buoyancy chambers mounted one upon the other. The 20-man raft is designed with a floor suspended between the flotation tubes. Because of this, it matters little which side lands in the water following inflation. One accessory container holds all the gear necessary for survival. Figures 10–42 and 10–43 illustrate the 12- and 20-man rafts, respectively.

The Mk 12 and Mk 20 rafts are equipped with THROW OUT type carrying cases. Because of the bulk of these rafts, they should be stowed near exits. In preparing to toss a raft overboard, the first action taken is the removal from its stowage place; second, it must be brought into position for a clear toss overboard where it will not be in danger of getting caught under protruding structures or wires; and third, make certain the raft will not get away after inflation. To insure against this possibility, the raft retaining line must be grasped firmly before tossing the raft out and jerking the cable release free of the cylinder discharge head. Hold on to the retaining cord to prevent loss of the raft. NEVER INFLATE A LIFE VEST OR RAFT INSIDE THE FUSELAGE.

With the Mk 12 raft, the main tube is inflated initially with CO_2, and the floor and top tube are inflated manually. With the Mk 20 raft, both tubes are inflated initially with CO_2. However, both rafts can be inflated manually through their topping-off valves by use of a hand pump.

Mk 20 Ejection System

The airplane equipped with this system is furnished with three 20-man life rafts and four 12-man life rafts. One 12-man life raft is stowed aft of the crew toilet and three aft of the passenger package net on the right sidewall. Two 20-man rafts are stowed in two compartments in the left inner wing and one in a compartment in the right inner wing. The compartments are lined to prevent damage to the rafts, and an adjustable rack is installed to support the

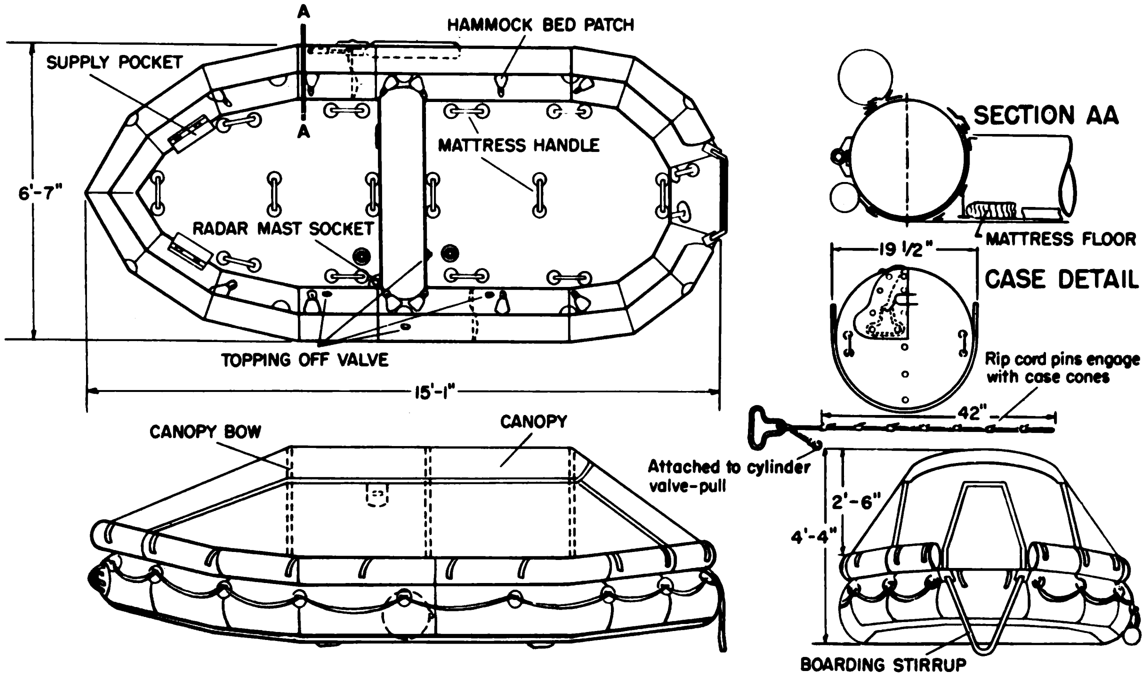


Figure 10–42.—12-man life raft.

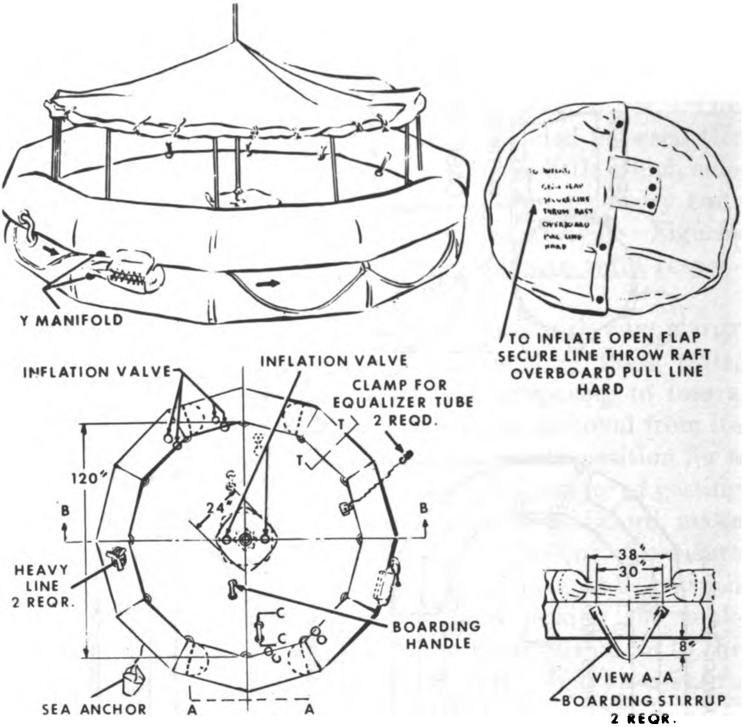


Figure 10–43.—20-man life raft.

CO_2 cylinder which inflates the raft. A hinged and latched cover encloses each compartment. The cover closes on a rubber seal that prevents water from entering the compartment. A trough, equipped with drains, is installed around the upper edge of the compartment to collect any water that enters around the edge of the door.

Each 20-man raft has attached to it a sealed, waterproof, flotable container holding the following accessories: Four repair plugs, one sea anchor, one flare kit, one first aid kit, one bailing bucket, two sponges, one signal mirror, one waterproof flashlight, one water container, one police whistle, one compass, one waterproof Bible, one waterproof booklet of instructions, four sea water distilling kits, four life raft rations, one curved sheath knife, one hand pump, and two paddles. A raft lanyard, a heaving line, and a lifeline are attached to the raft.

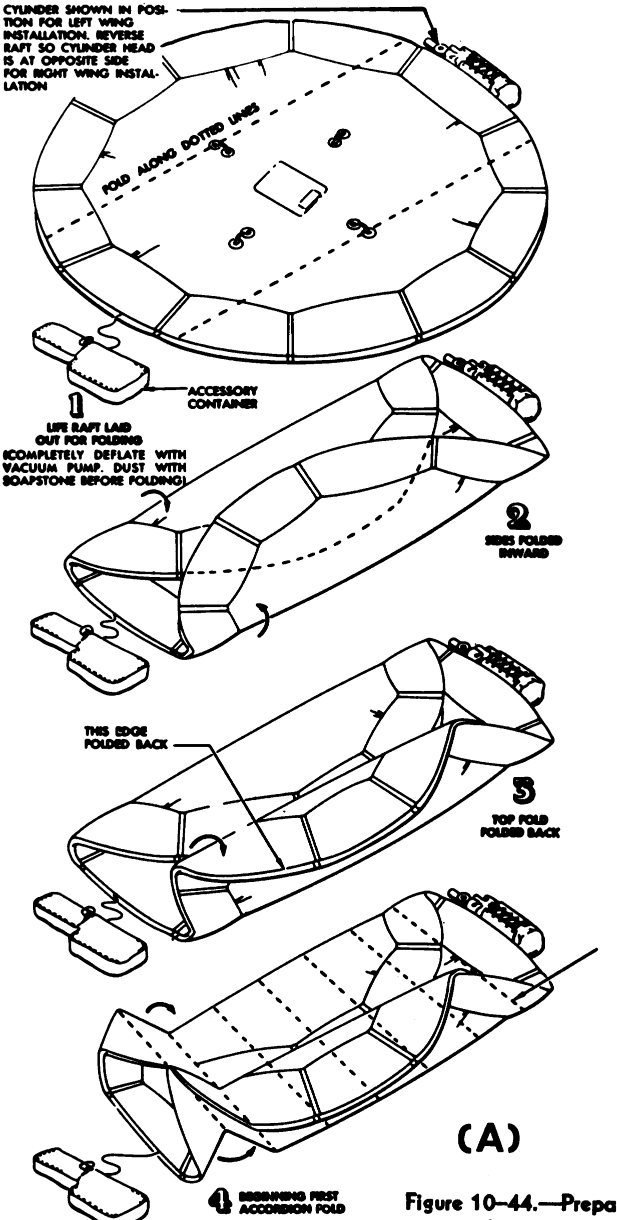
MAINTENANCE.—Before installing 20-man life rafts, visually inspect for abraided and scuffed areas, mildew, loosened screws and patches, wrinkles and air pockets, and deterioration of the fabric.

Rafts that are SLIGHTLY MILDEWED may be cleaned using a cloth moistened with rubber solvent, aromatic naphtha (Specification TT–N–96, type 1, grade B). ***Caution:*** Use solvent sparingly to avoid loosening the rubber coating of the fabric.

After cleaning with solvent, apply two coats of light, self-curing cement (Specification Mil–C–5539, Type A), to entire raft and allow to dry for 24 hours before folding or inflating the raft.

The following procedure applies to the repair of tears or abrasions in the surface of the flotation tubes between seams, and not to internal bulkheads or diaphragms:

1. Lay damaged area of raft flat on worktable and determine the size of the tear. Damage less than 2 inches in length or diameter may be repaired by the application of an outside patch. Damage exceeding 2 inches in length or diameter requires an inside patch as well as an outside patch.
2. Prepare inside patch with straight sides to extend 1½ inches from all extremities of the tear. Round off corners of patch and mark crosslines 1½ inches from edge of patch to properly locate patch under damaged area.
3. To insure that the inside surface of the raft is powdered properly in the area of the repair, place a small handful of talc through the tear approximately 12 inches from the damaged area. Care must now be taken to prevent distribution of the talc prior to completion of the repair.
4. Using a cloth moistened with solvent, clean an area of the inside surface at the tear slightly larger than the patch, and allow to dry thoroughly.
5. Apply two coats of extra light (self-curing cement), and three coats of heavy self-curing cement to the cleaned area, and also to the side of the inside patch to be applied.


CYLINDER SHOWN IN POSITION FOR LEFT WING INSTALLATION. REVERSE RAFT SO CYLINDER HEAD IS AT OPPOSITE SIDE FOR RIGHT WING INSTALLATION
FOLD ALONG DOTTED LINES
ACCESSORY CONTAINER
1
LIFE RAFT LAID OUT FOR FOLDING (COMPLETELY DEFLATE WITH VACUUM PUMP. DUST WITH SOAPSTONE BEFORE FOLDING)
2
SIDES FOLDED INWARD
THIS EDGE FOLDED BACK
3
TOP FOLD FOLDED BACK
4
BEGINNING FIRST ACCORDION FOLD

(A)

Figure 10-44.—Preparation for ejection.

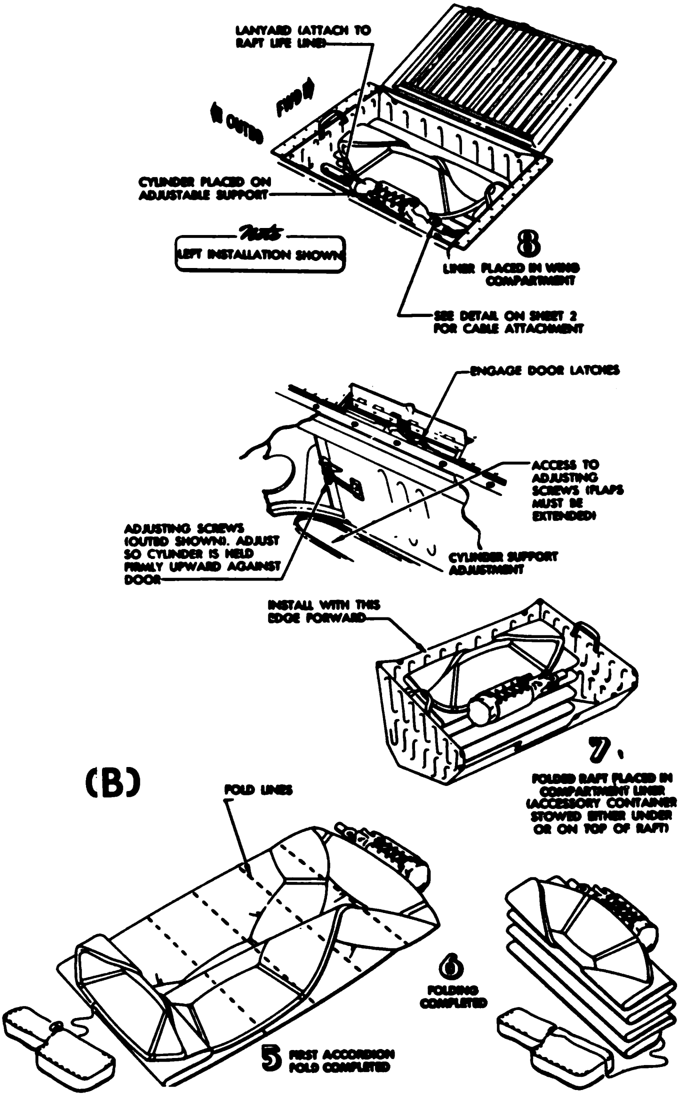

LANYARD (ATTACH TO RAFT LIFE LINE)
FWD
OUTBD
CYLINDER PLACED ON ADJUSTABLE SUPPORT
Note
LEFT INSTALLATION SHOWN
8
LINER PLACED IN WING COMPARTMENT
SEE DETAIL ON SHEET 2 FOR CABLE ATTACHMENT
ENGAGE DOOR LATCHES
ACCESS TO ADJUSTING SCREWS (FLAPS MUST BE EXTENDED)
ADJUSTING SCREWS (OUTBD SHOWN). ADJUST SO CYLINDER IS HELD FIRMLY UPWARD AGAINST DOOR
CYLINDER SUPPORT ADJUSTMENT
INSTALL WITH THIS EDGE FORWARD
7
FOLDED RAFT PLACED IN COMPARTMENT LINER (ACCESSORY CONTAINER STOWED EITHER UNDER OR ON TOP OF RAFT)
(B)
FOLD LINES
6
FOLDING COMPLETED
5
FIRST ACCORDION FOLD COMPLETED

Figure 10–44.—Preparation for ejection—Continued.

Allow each coat to dry thoroughly before applying successive coats (except the last coat).

6. While the last coat of cement is still slightly tacky to the touch, apply patch. To do this, fold patch lengthwise in the shape of the letter U, and insert patch using cross lines to coincide with extremities on one side of tear. Working from attached edge of fabric to edge of the patch, smooth out any wrinkles with a stitcher. Butt torn edges. Remove wrinkles and roll area thoroughly with a 2-inch rubber roller.

7. Grasp sides of flotation tube and pull apart to scatter the handful of talc previously placed in tube.

8. Prepare outside patch of proper shape and size to provide not less than ½-inch overlap of the inside patch in all directions. PINKING SHEARS should be used for cutting this patch.

9. Clean and apply cement to damaged area on outside surface of raft and patch, using same procedures outlined in steps 4 and 5.

10. Center patch and apply to the prepared surface using the 2-inch roller and stitcher as necessary.

11. Dust repaired area lightly with talc and allow 5 DAYS CURING TIME.

12. INSPECT AND PRESSURE TEST RAFT in accordance with applicable publications before using.

When using an outside patch only for repair of an abrasion, the patch should extend 2 inches in all directions beyond the abraded area. All outside patches should be cut with pinking shears.

FOLDING AND INSTALLATION FOR EJECTION.—This system uses no submersion switch or actuating control cylinder. It is a remote type manual system. As an example, the following steps apply to folding and installing the 20-man life raft for ejection from a particular aircraft:

1. Place the deflated raft on a flat surface. The position of the inflating cylinder will determine whether the raft is stowed in a left- or right-wing compartment. If the cylinder is facing in the wrong direction, turn the raft completely over.

2. Fold the raft in thirds so the cylinder remains at the end of the raft.

3. Fold back one-half of the top fold.

4. Make five folds in accordion pleats so that the cylinder is resting on top of the rectangular bundle. (See fig. 10–44.)

5. Set the raft into the proper wing compartment. The operating head of the raft cylinder must face inboard with the cylinder at the aft side of the compartment. (See fig. 10–44.) Place the cylinder on the supporting rack. The

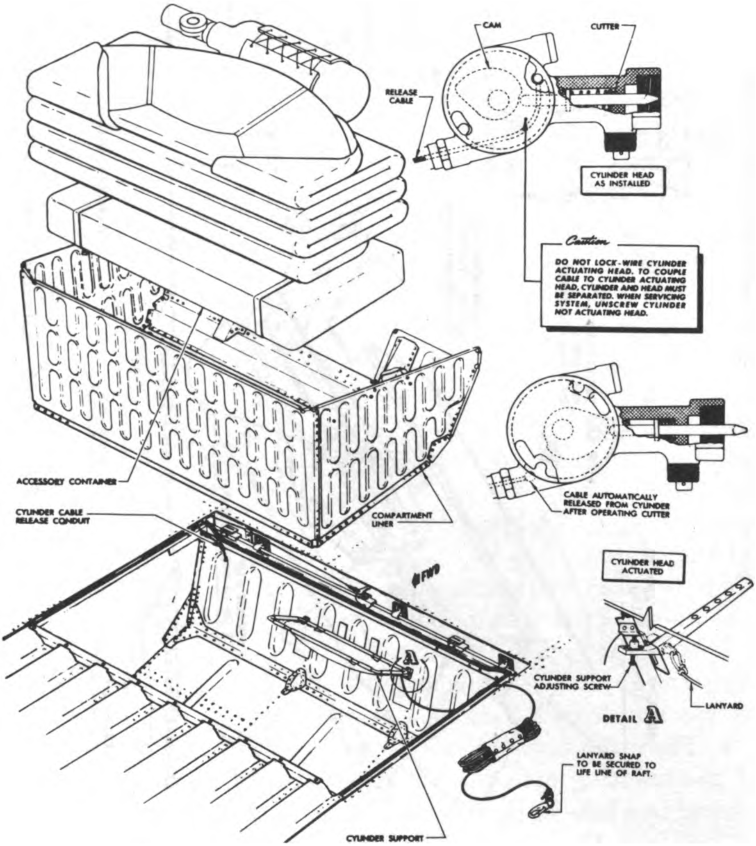
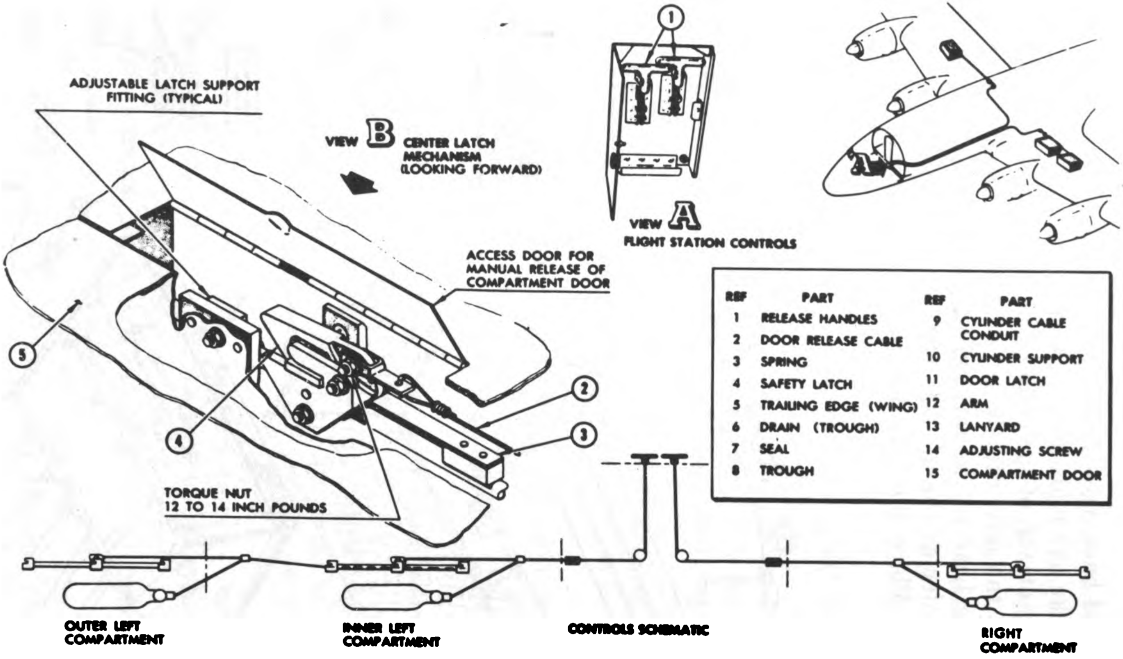

CAM
CUTTER
RELEASE CABLE
CYLINDER HEAD AS INSTALLED
Caution
DO NOT LOCK-WIRE CYLINDER ACTUATING HEAD. TO COUPLE CABLE TO CYLINDER ACTUATING HEAD, CYLINDER AND HEAD MUST BE SEPARATED. WHEN SERVICING SYSTEM, UNSCREW CYLINDER NOT ACTUATING HEAD.
ACCESSORY CONTAINER
CYLINDER CABLE RELEASE CONDUIT
COMPARTMENT LINER
CABLE AUTOMATICALLY RELEASED FROM CYLINDER AFTER OPERATING CUTTER
FWD
CYLINDER HEAD ACTUATED
A
CYLINDER SUPPORT ADJUSTING SCREW
LANYARD
DETAIL A
LANYARD SNAP TO BE SECURED TO LIFE LINE OF RAFT.
CYLINDER SUPPORT

Figure 10–45.—Relationship of cylinder and head.


ADJUSTABLE LATCH SUPPORT FITTING (TYPICAL)
VIEW B CENTER LATCH MECHANISM (LOOKING FORWARD)
ACCESS DOOR FOR MANUAL RELEASE OF COMPARTMENT DOOR
TORQUE NUT 12 TO 14 INCH POUNDS
1
2
3
4
5
VIEW A FLIGHT STATION CONTROLS
OUTER LEFT COMPARTMENT
INNER LEFT COMPARTMENT
CONTROLS SCHEMATIC
RIGHT COMPARTMENT

REF	PART	REF	PART
1	RELEASE HANDLES	9	CYLINDER CABLE CONDUIT
2	DOOR RELEASE CABLE		
3	SPRING	10	CYLINDER SUPPORT
4	SAFETY LATCH	11	DOOR LATCH
5	TRAILING EDGE (WING)	12	ARM
6	DRAIN (TROUGH)	13	LANYARD
7	SEAL	14	ADJUSTING SCREW
8	TROUGH	15	COMPARTMENT DOOR

Figure 10–46.—Life raft location and control system.

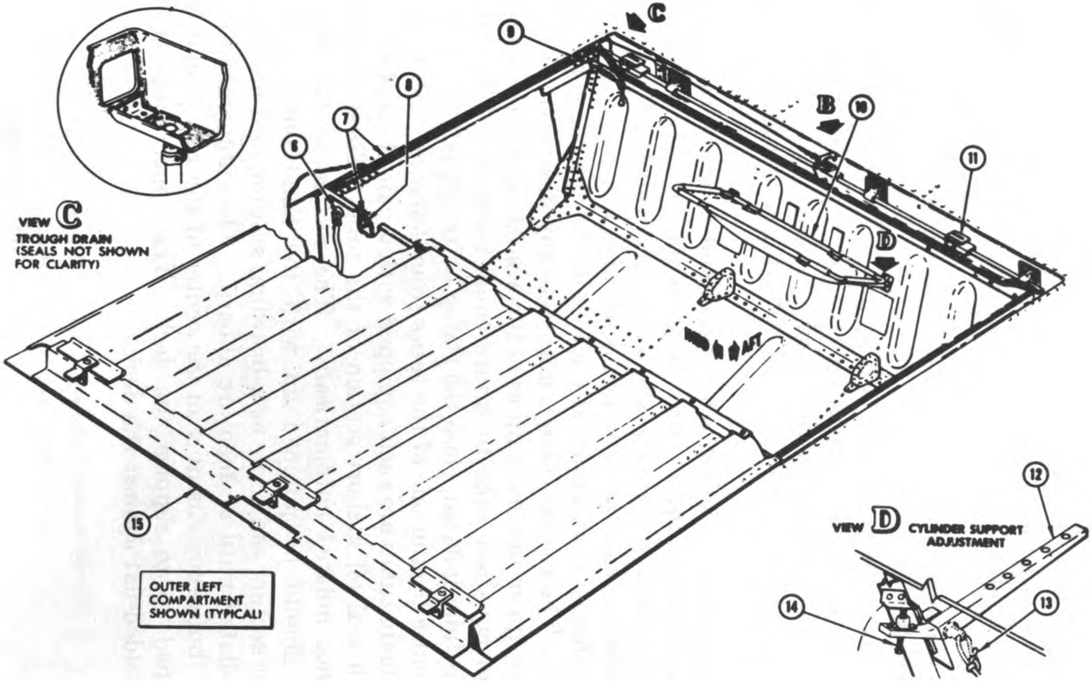


Figure 10–46.—Life raft location and control system—Continued.

accessory container may be placed in the bottom of the compartment before the raft is stowed. (See fig. 10–45.)

6. Connect the release cables at the quick-disconnect fittings. (See details in figs. 10–44 and 10–45.)

7. Connect the raft lanyard to the raft lifeline, and place the bag holding the lanyard on top of the life raft. (See fig. 10–45.)

8. Close and latch the compartment door or cover. (See fig. 10–46.)

9. Turn the adjusting screws on the cylinder support rack so the cylinder is held tightly against the compartment cover. Access to adjusting screws is through the wing flap opening. (See detail D, in fig. 10–46, and detail A, in fig. 10–45.)

OPERATION.—Pulling the release handles on the front face of the partition in the flight cabin simultaneously unlatches the compartment covers and opens the valves of the CO_2 cylinders of each raft by means of cable controls. As each raft inflates, it automatically ejects itself from the compartment. The release cable is automatically disconnected.

The upper and lower tubes of the Mk 20 raft are connected by an equalizer tube to insure equal inflation. When the raft is fully inflated, close the clamp on the equalizer tube to prevent a leak in one of the tubes from deflating both tubes. The main tubes are each equipped with a pair of diaphragms which seal off a short section of the tube. These sections are not inflated automatically. The section in the lower tube should be pumped up with the hand pump. The upper section can serve as a boarding station, and need not be inflated until all men are aboard. The submerged auxiliary buoyancy chamber in the center of the raft should be pumped up to support the deck. The upper chamber is left folded flat against the deck.

QUIZ

1. On the Mk 2, Mk 4, and Mk 7 life rafts
   - a. only the Mk 7 has an inflatable seat
   - b. all have inflatable seats
   - c. the Mk 4 has an inflatable seat
   - d. the Mk 2 has an inflatable seat
2. The Mk 7 life raft flotation tube is divided into two separate compartments by means of
   - a. an internal horizontal bulkhead
   - b. an internal vertical bulkhead
   - c. either of the above
   - d. two internal vertical bulkheads
3. Oarlocks on life rafts are used for
   - a. rowing, steering, and as a mast holder
   - b. rowing and steering only
   - c. rowing, steering, as a mast holder, and sea anchor attachment
   - d. Rowing and rigging a sail only
4. The supply pocket, and supply pocket and bailer, are standard equipment on life rafts. Of the two
   - a. the supply pocket is detachable
   - b. both are detachable
   - c. neither is detachable
   - d. the supply pocket and bailer is closed by means of a slide fastener
5. Topping-off valves on life rafts are used
   - a. for increasing or decreasing internal flotation tube pressures
   - b. to increase pressure only
   - c. in conjunction with the CO_2 inflation system
   - d. primarily to release excessive pressure
6. A Mk 4 life raft is supplied with
   - a. two six-foot oars and one extra oar section
   - b. three complete oars and one additional oar section
   - c. three five-foot oars only
   - d. three six-foot oars and one additional oar section
7. The reflective material on the oar blade is for
   - a. night use only
   - b. day use only
   - c. day or night use
   - d. reflecting sunlight on very bright days

8. The purpose of the retaining line is to
    a. secure the raft to the aircraft
    b. secure the raft equipment to the raft
    c. prevent the raft from drifting away from the aircraft before it is boarded
    d. secure the raft to the user
9. The plastic water storage bag
    a. holds five quarts of water
    b. is stowed in life raft equipment containers
    c. can be used to protect various items from salt water
    d. all of the above statements are true
10. When a dye marker packet is released at sea, it
    a. produces a bright orange color on the water
    b. takes 40 minutes to dissolve
    c. completely loses its value after one hour
    d. produces a yellowish-green fluorescent color for at least one and one-half hours
11. The capacity of the desalting kit, for making drinkable water from sea water, is
    a. 6 pints per day
    b. 7 pints
    c. 2 pints per day
    d. unlimited
12. The ability of the solar still to produce drinkable water from the sea depends primarily on
    a. the atmospheric temperature
    b. appropriate weather conditions and its mechanical condition
    c. the section of the world in which it is to be used
    d. the ability of the user
13. The life raft paulin can be used as a
    a. sail and raincatcher
    b. camouflaging device and signal
    c. cover for protection from the weather
    d. all of the above statements are true
14. A leak test of a Mk 4 life raft requires
    a. 24 hours
    b. 1 hour
    c. 25 hours
    d. 50 hours
15. A raft can be surveyed when
    a. patching the internal bulkhead is required
    b. patching the inflatable seat is required
    c. a hole in the raft is over six inches long
    d. the bottom has a hole in it

16. The two solvents that are recommended for use with life raft cement are
    a. benzol and turpentine
    b. naphtha and turpentine
    c. benzol and naphtha
    d. benzol and alcohol
17. The proper curing time for type A cement used on life rafts on approximately 70° F. is
    a. 30 days
    b. 15 days
    c. 5 days
    d. 24 hours
18. The number of coats of cement applied to a patch 2 inches in diameter is
    a. 2
    b. 6
    c. 3
    d. 4
19. The first two coats of cement mixed for patching are
    a. 3 parts solvent, 1 part cement
    b. thinned with equal amounts of solvent and cement
    c. 4 parts solvent, 1 part cement
    d. 3 parts cement, 1 part solvent
20. The raft is constructed of 2-ply
    a. rubberized high grade cotton fabric
    b. rubberized nylon fabric
    c. rubberized type "O" cotton
    d. ripstop nylon fabric with rubber compound between the plies
21. PK–2 kits are repacked every
    a. 60 days
    b. 90 days
    c. 120 days
    d. 30 days
22. The specification number of the self-curing cement used on life rafts is
    a. MIL–C–5539, Type A
    b. MIL–R–5567, Type A
    c. MIL–S–6637, Type A
    d. MIL–C–3946, Type A
23. The outside patch on a raft should overlap the inside patch in all directions by
    a. 1½ inches
    b. 2 inches
    c. ½ inch
    d. 3 inches

24. Which of the following is/are part of the Mk 20 raft?
   a. Equalizer tube
   b. Diaphragms
   c. Protective canopy
   d. All the above

CHAPTER 11

AIR-SEA RESCUE EQUIPMENT

Air-sea rescue equipment is designed to be dropped in compact kit form to survivors. Some of them can be dropped in free-fall fashion, while others are too fragile for such rough treatment, and must be delivered by small cargo type parachutes. Literally, there is no limit (physical) to the different kinds of equipment that can be rigged for emergency rescue operation. Where there is no physical limit, there is, however, a mental kind of limit. The mental limit, to a great extent, depends on the initiative and the inventiveness of the Parachute Rigger, and how well he has prepared himself to cope with emergency rescue techniques. Although the Coast Guard is especially trained for this kind of service, the Navy, by virtue of its flexibility, must be prepared to take care of its own and others when in a position to do so. There are a number of tailor-made droppable kits available through the supply system of the Navy. This chapter will define their contents and, where necessary, will offer additional information concerning inspection and testing procedures as well as the operation of the equipment.

AR–4 RESCUE ASSEMBLY

The AR–4 droppable lifeboat, designed for dropping to personnel, is a four-man pneumatic life raft of double tube construction. It is complete with a lateen type sailing rig, mast, rudder, keel, weather shield, sun canopy, sea anchor, and an inflatable floor. The weight of the unit, properly padded and protected for dropping, and ready for installation in the aircraft, is approximately 110 pounds. An instruction booklet is provided with each assembly, stowed in the starboard bow supply pocket. The booklet contains complete

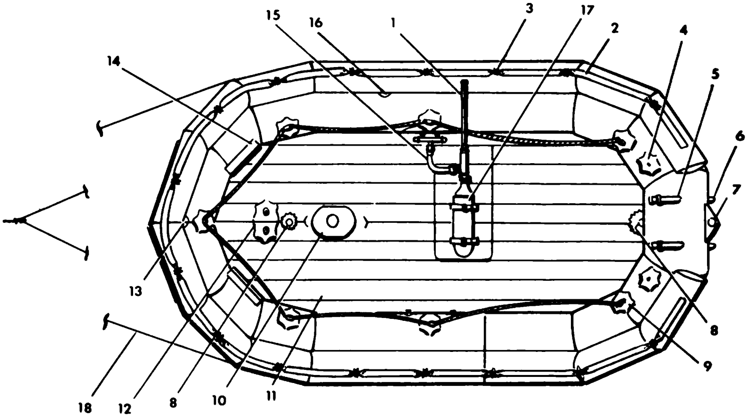


Figure 11–1.—AR–4 lifeboat (basic plan).

1. **CO$_2$ valve cable—flexible conduit.**
2. **Weather shield.**
3. **Weather shield tie down.**
4. **Patch for sheet lead—equip with plastic bull's-eye to receive sheet line.**
5. **Motor mount buckle straps.**
6. **Fabric loops for motor mount.**
7. **Rudder lock.**
8. **Socket to receive oar length for shield rigging.**
9. **Lifeline patch inboard.**
10. **Sleeve for mast insertion into keel.**
11. **Inflatable floor (approx. 2 inches high).**
12. **Valves for 2-compartment floor.**
13. **D-ring for bow mast stay.**
14. **Stowage pockets.**
15. **CO$_2$ hose assembly.**
16. **D-ring for starboard mast.**
17. **CO$_2$ cylinder and valve.**
18. **Sea anchor bridle.**

instructions for operating the boat, including all equipment. Figures 11–1 and 11–2 illustrate the AR–4 assembly.

Equipment

INFLATABLE FLOOR.—A two-compartment removable inflatable floor is inflated through the topping-off valves provided. The size of the floor is designed so that it will not chafe the flotation tube of the boat. Removed, it can be used as an auxiliary means of flotation.

CO$_2$ SYSTEM.—Only the main flotation tube is inflated with CO$_2$. The remaining inflation chambers must be inflated with hand pumps. A wrench, suitable for detaching the CO$_2$ cylinder from the boat, is securely attached adjacent to the cylinder.

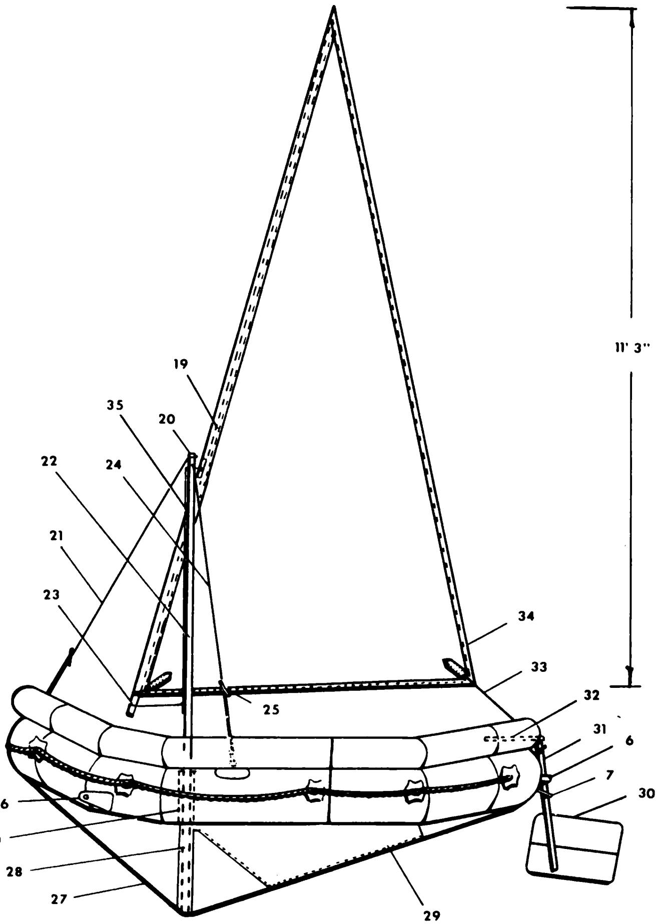


Figure 11–2.—AR–4 lifeboat (rigged for sailing).

19. Yardarm sleeve in sail.
20. Mast stay and halyard fitting.
21. Bow mast stay.
22. Mast.
23. Yardarm.
24. Stay.
25. Stay adjustors—wooden.
26. Sea anchor D-ring.
27. Keel cable.
28. Fabric sleeve to receive mast.
29. Fabric keel.
30. Rudder—hinged through supports.
31. Rudder post.
32. Tiller.
33. Sail sheet lead.
34. Sail.
35. Halyard.

SAILING RIG.—A mast yardarm is formed from sections of oars which are the same as those used in the standard type multiplace rafts. Oar sections necessary for forming the mast yardarm are as follows:

Oar and section	*No. required*
6-ft. oar (Section A)	2
6-ft. oar (Section B)	6
6-ft. oar (Section C)	2

The mast is made up of 1 section A LENGTH and 2 section B LENGTHS. The yardarm consists of 1 section A LENGTH and 4 section B LENGTHS. Section C LENGTHS are used with any of the other sections when paddles are needed.

MAST STAY AND HALYARD FITTING.—One wooden fitting is supplied to fit the top of the mast to hold the three mast stays and receive the sail halyard as shown in figure 11–2.

D-RING ASSEMBLIES FOR MAST STAYS.—These assemblies consist of 1¼-inch cadmium-plated D-RINGS secured to type O fabric patches by lengths of nylon webbing 1-inch wide, passed through the ring, and stitched to fabric patches. These rings when installed must be able to withstand a straight-away pull of at least 300 pounds.

MAST HALYARD CLEAT.—This is a metal cleat designed for attachment by clamping to the mast. It is used for securing the sail hoist and yardarm securing lines.

SAIL.—The sail material is made from 2-ounce sailcloth. Its color is blue, and the sail is equipped with a fabric sleeve to receive the yardarm.

RUDDER.—A collapsible wooden rudder folds in half, lengthwise, through the middle on hinges.

MOTOR.—No motor is supplied with the assembly; however, it is equipped to receive one of low horsepower.

MARKINGS ON THE RAFT.—When markings become obliterated, consult applicable publications for information that will direct the proper phrasing, size of the letters, paint or other liquid vehicle to use, and the location of the instructions to be reapplied.

HAND PUMPS.—Two plastic hand air pumps are supplied for emergency inflation.

NYLON CORD.—One hundred feet of type I nylon cord is stowed in the supply pocket, and is intended for general utility purposes.

WHISTLE.—One police-type whistle, equipped with a lanyard 3 feet long is provided.

BAILING SPONGE.—One sponge is provided.

EQUIPMENT CONTAINERS.—Two equipment containers are supplied with each boat. One is used to contain the following sailing equipment: Sail, mast, and yardarm sections; mast stay and halyard fittings; and rudder assembly. The other container holds all other items of equipment, EXCEPT THE SEA ANCHOR, INSTRUCTION BOOKLET, and BAILING BUCKETS. The contents are marked on the containers in ¼-inch letters.

CARRYING CASE.—The boat is packed in the carrying case. The outer color of the case is orange yellow. The case consists of an outer ply of type II fabric (in accordance with specifications) backed up by a ply of 8-ounce cotton duck. The ends are closed by snap fasteners. The longitudinal opening is enclosed by a locking pin-and-cone assembly attached to the CO_2 valve cable by a snaphook fastener. This assembly is covered by a fabric flap, closed by snap fasteners. A pull on the valve cable releases the locking pins on the case before actuating the CO_2 valve. Two webbing straps are provided to suspend the unit from aircraft bomb racks. Each strap is made from webbing 2 inches wide (400-pound minimum breaking strength) equipped with a parachute harness V-RING on each end. Each strap is also equipped with buckles for adjustment. The maximum length of each strap assembly extended is 65 inches. A V-RING is installed at one end of the case at the base of the opening.

SEA ANCHOR.—One sea anchor is supplied with each raft, attached by a bowline knot to its mooring patch. The sea anchor MUST NOT be rolled inside the boat, but must be stowed in the boat carrying case, thus permitting the sea anchor to fall into the water upon inflation of the boat. When packing, care must be taken to insure that the bowline does not foul and bind the boat during inflation.

BAILING BUCKETS.—Two bailing buckets, constructed of

Table 11-1.—AR-4 lifeboat equipment

Article	Quantity	Furnished by	Installed by	Location
1. Anchor, sea	1	Contractor	Contractor	Boat package.
2. Bag, water, stowage	4	do	do	Survival equipment container.
3. Booklet, instruction	1	do	do	Starboard bow pocket of boat.
4. Bucket, bailing	2	do	do	Port bow pocket of boat.
5. Cleat, mast halyard	1	do	do	Sailing equipment container.
6. Compass, card type	1	do	do	Survival equipment container.
7. Container, equipment	2	do	do	Boat package.
8. Fitting, stay and halyard	1	do	do	Sailing equipment container.
9. Kits, desalting	4	Government	do	Survival equipment container.
10. Kits, repair	1	Contractor	do	Starboard bow pocket of boat.
11. Jackknife	1	Government	do	Survival equipment container.
12. Marker, dye pack	6	do	do	Do.
13. Mirror, signaling	1	do	do	Do.
14. Paulin	1	Contractor	do	Do.
15. Pump, hand	2	do	do	Do.
16. Reflector, corner*	1	Government	Government	Do.
17. Rudder	1	Contractor	Contractor	Sailing equipment container.
18. Sail	1	do	do	Do.
19. Sections, oars, mast, yard-arm.	2 Sec. A	do	do	Do.
	6 Sec. B	do	do	Do.
	2 Sec. C	do	do	Do.
20. Signals, distress (day and night).	3	Government	do	Survival equipment container.
21. Sponge, bailing	1	do	do	Do.
22. Stays, mast	3	Contractor	do	Sailing equipment container.
23. Whistle	1	Government	do	Survival equipment container.

*When available, the Transceiver, Model AN/PRC-17, shall be substituted for the corner reflector.

TYPE N fabric, 8 inches in diameter and 12 inches deep, are supplied with each boat.

JACKKNIFE.—One jackknife, equipped with a 3-foot lanyard, is supplied with each boat.

ADDITIONAL EQUIPMENT.—Table 11-1 illustrates where the additional equipment is stowed in the AR-4 assembly; and also where the equipment previously defined is stowed.

Packing the Equipment

EQUIPMENT.—Place the equipment in the containers as previously outlined. The bailing buckets are stowed in the port bow pocket. All rigid parts must be wrapped individually with cloth or felt paddings to protect the parts and the raft fabric from damage. The mast and oar sections must be secured together and be padded at both ends. The equipment containers are stowed adjacent to the CO_2 cylinder, one on each side of the cylinder, and each container is secured to the inside liftline by a 6-foot length of TYPE III nylon line.

INFLATING EQUIPMENT.—The metal parts of the manifold and the CO_2 cylinder valve must be wrapped carefully with wads of cheesecloth or felt. The cylinder must also be padded at both ends. The CO_2 cylinder assembly is the heaviest single item of equipment for its size, and must be prevented from damaging the boat when the unit is dropped at or below 100 m. p. h. indicated airspeed.

METAL PARTS.—All metal parts, such as D-RINGS, BUCKLES, VALVES, etc., must be wrapped securely with cloth or felt padding.

RUDDER.—The rudder is collapsed completely, bound together, and stowed well-padded, in the equipment container.

Folding the Lifeboat

First of all, the boat must be deflated completely. Then spread the boat flat so that gear may be stowed on it. Fold each side toward the middle and on top of all stowed gear. The CO_2 actuator control cable must fall on top of the starboard fold in a manner so that it can be operated after the boat is rolled.

Roll the boat from each end toward the CO_2 cylinder at the center. When rolling from the bow to the cylinder, care must be taken in order that the keel cable will not foul during the inflation of the boat. The cable is held as near as possible to the center of the bottom during the rolling operation. The keel must be extended flat on one side. The CO_2 actuating control must be kept clear.

The boat is placed in the carrying case, folded and rolled, with the open portion up, and alined with the carrying case opening. This is to assure that the boat will float and inflate right side up on the water. After this, the case is closed as the releasing assembly is engaged.

The following inspections, as applicable, should be conducted on AR–4 lifeboats before they are placed in service, after receipt from stock, and semiannually thereafter:

1. Inflate boat with installed inflation system to ascertain that all parts of this equipment perform properly.
2. Inspect metal parts for evidence of corrosion, and examine body of boat, weather shield, spray tube, and inflatable floor for deterioration.
3. Remove the CO_2 cylinder from boat. Check manifold for leakage with soapy water.
4. Deflate boat using a deflation or suction pump to insure complete removal of CO_2 gas.
5. Inflate one compartment of the boat with air to 2.0 pounds per square inch pressure. Remove the cap from the topping-off valve in the deflated compartment. After one hour, again check pressure and adjust, if necessary, to the original pressure of 2.0 pounds per square inch. Note temperature. Allow compartment to remain inflated for 24 hours.
6. Conduct the same test on the other compartment of the boat.
7. Test the spray tube in the same manner as the one main tube compartment.
8. If the pressure of either compartment or spray tube drops to less than 1.25 pounds per square inch after cor-

rection for temperature changes, consider the boat unfit for issue and check it further for leaks; if practicable, have it repaired.

9. Test each compartment of the inflatable floor as above with the exception that the initial pressure should be 1.0 pound per square inch with a drop to 0.5 pound per square inch permitted after 24 hours.

10. Deflate raft, using deflation or suction pump to insure complete removal of air.

11. Attach correctly charged cylinder (tolerance ±½ ounce of total weight stenciled on cylinder) to raft and tighten all connections.

12. Check all sailing, signaling, and survival equipment for completeness, proper stowage location and, where practicable, operation.

13. Examine raft case for oil and acid stains, and for any visible defects or deteriorations likely to damage the contents of the case.

Where stowage space permits, the AR–4 assembly is carried in aircraft operating in cold weather regions. It is more suitably equipped for cold operations than the standard multiplace life rafts.

ARCTIC SURVIVAL KIT

The Arctic survival kit was designed to be dropped by parachute from multiengine aircraft. Chest type parachutes are easily engaged with the rings of a webbing yoke which holds and centralizes the other three encircling straps.

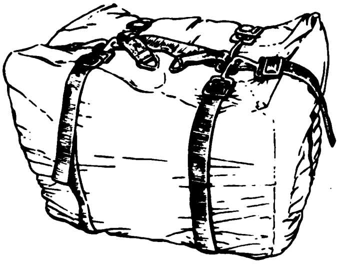


Figure 11–3.—Air droppable Arctic survival kit (ADA kit).

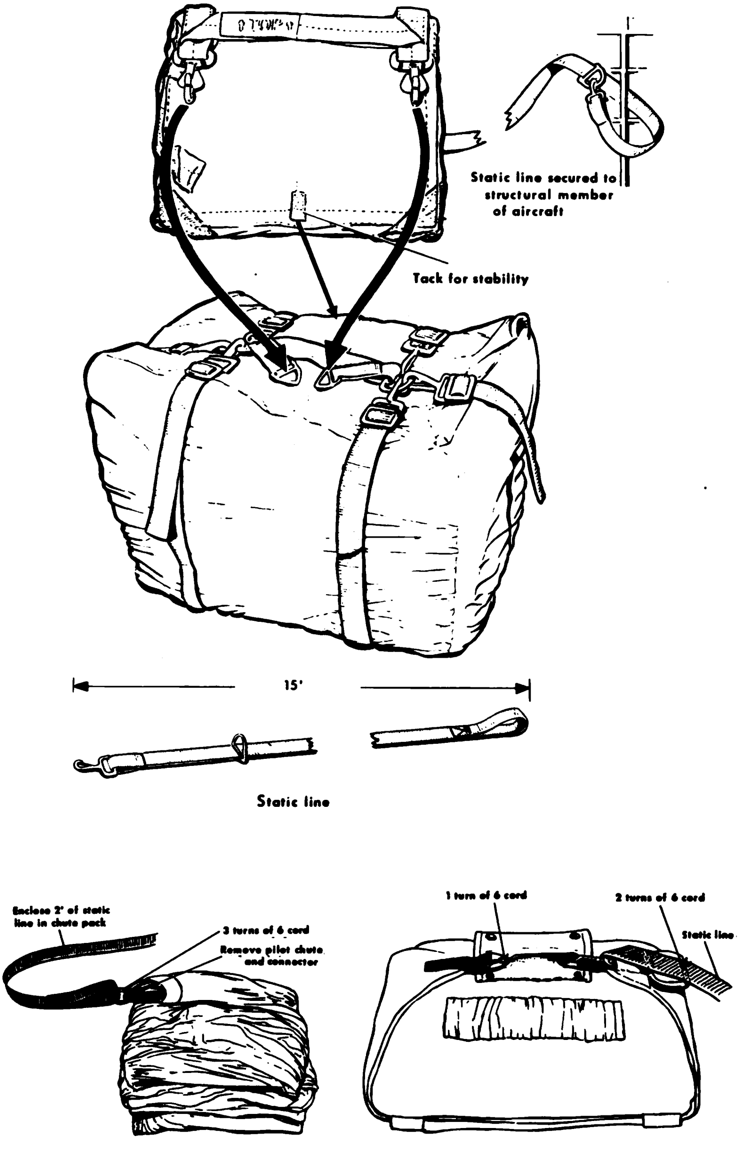

Static line secured to structural member of aircraft
Tack for stability
15'
Static line
Enclose 2' of static line in chute pack
3 turns of 6 cord
Remove pilot chute and connector
1 turn of 6 cord
2 turns of 6 cord
Static line

Figure 11–4.—Rigging and dropping the ADA kit.

From figure 11-3, it can be seen that the straps are adjustable. Figure 11–4 illustrates one application of a chest type parachute to the kit. Actually, any cargo type parachute of a suitable size (24 to 28 feet in diameter) could be used in this rig.

The purpose of the kit is reflected in the items it contains. Any of the following items can be added or eliminated for substitution purposes in accordance with local requirements:

Antichap lipstick.
AN/PRC–17 transceiver.
C–3 rations.
Bag, sleeping, M–1949.
Candles, 1¼ by 5 inches.
Cord, Nylon (Type 1), 50 feet.
Signal, Distress (Day and night), Mk 13 Mod 0.
Drawers, Men's wool, size 42.
File, 6-inch.
First aid kit, Aero.
Fishing equipment.
Flashlight.
Fuel, canned, Sterno, No. 4006 in 2⅝ cans.
Mittens, Arctic, Mil–M–834–B.
Tablets, heating, fuel, Trioxane (51–F–2077).
Stove assembly (R83–S–793070).
List of contents (ADA–2 kit).
M6 rifle/shotgun 22 cal/410 and ammunition.
Survival kit (axe and saw).
Batteries, flashlight, BA–30 "C" Navy, 1.5 volts.
Brush, mountain.
Survival Manual, AF Manual 64–5.
Frying pan, Navy Spec. M560a, 7½ in. Dia. S/N R64P739.
Knife, survival, pilot's, with sheath.
Undershirts, wool, size 42.
Code, signaling.
Matches, box of waterproof.
Mosquito headnets M–1944.
Parkahood, detachable.
Paulin Mk 7.
Scarfs.
Signaling mirror.
Snare, self-locking, size 0, Raymond Thompson Co. or equiv.
Socks, wool, cushion sole, O. D. size 12.
Sun glasses (with case).
Tissue, facial, Kleenex or equiv. Std. size.
Whistle.
Wire, copper, soft or annealed—50 feet.

ADSK–1.—This kit is designed to be carried on the bomb rack of fighter aircraft. It is shaped similar to a bomb, and is dropped by a 9-foot parachute packed in one end of the container. It can be dropped at speeds up to 250 miles per hour. The contents of the kit are about the same as its counterpart which is dropped from multiengine aircraft. Figure 11–5 illustrates the ADSK–1 kit.

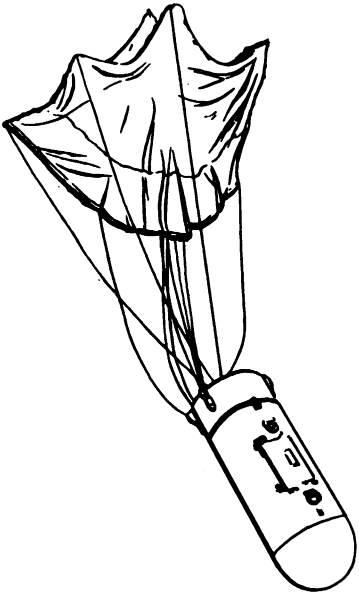


Figure 11-5.—The ADSK-1 kit.

Ration Kit

(ADR-1)

This kit is designed to provide distressed personnel a maximum amount of water so they can maintain the pint-of-water-a-day considered the minimum requirement for survival. The size of the kit when packed is 21 x 8 x 6 inches. It can be carried and can be dropped from any type aircraft with suitable space. No special dropping technique is required to release the kit from aircraft as it is small enough to be thrown from a cockpit. When the kit is dropped, the airplane should approach the area as slowly as possible (90 to 100 IAS—indicated air speed) and at about 100 feet altitude. The kit is buoyant and floats high in the water. In view of a commonsense approach, the kit should be dropped upwind of survivors. The kit can be secured to a parachute harness or other emergency gear by means of a lanyard and snaphooks provided. A list of the equipment follows:

4 Desalting kits
1 Water storage bag
1 Solar still
1 Jackknife
6 Ration tablet containers
Length of cotton twine

Signaling Kit

(ADS-1)

The signaling kit is designed to supplement the communication equipment of survivors. It is somewhat smaller (15½ x 5⅝ x 7 inches) than the ration kit and can be dropped in the same way. The signaling kit contains the following items:

1 Flashlight with batteries
6 Dye markers
1 Signaling mirror
6 Distress signals
1 Whistle
Length of cotton twine

Radio Transmitter

(AN/CRT-3)

The emergency radio transmitter is used to transmit distress signals, and is carried in most multiengine aircraft. It is also carried in all rescue aircraft and can be dropped to survivors by means of a parachute attached to the container. The container holds the transmitter with the crank attached, one collapsible box kite, one signal light, two hydrogen generators, two transfer units, two balloons, and two spare aerials. The transmitter has a range up to 1,600 miles, depending on atmospheric conditions. (See fig. 11–6.)

If at all possible, the transmitter should be dropped over water, for the possibility of damage to the transmitter is very great when dropped on land. When it is dropped by parachute, the static line should be secured to some part of the aircraft, the aircraft slowed down to its slowest safe speed, and the transmitter dropped at 300 to 500 feet. The direction of drift should also be taken into consideration when making the drop. If the transmitter is dropped to men in water, it should be dropped upwind; to men in a raft, downwind. In case more than one item is to be dropped, they should be tied together.

If the aircraft is ditched, the transmitter should not be tossed out until the aircraft comes to a complete stop, for there may be more than one impact. When the aircraft has stopped, the container should be thrown out an escape hatch. It will float and can be picked up after other equipment has been removed and the raft has been boarded. If convenient, it should be tied to the raft.

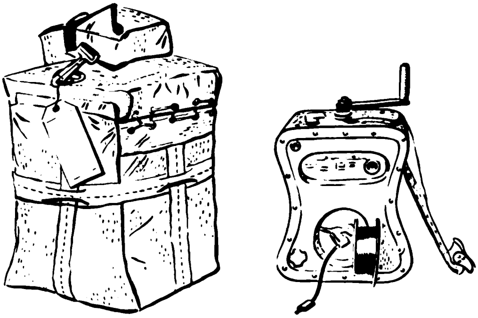


Figure 11–6.—AN/CRT–3 radio transmitter.

There are two means of raising the aerial, by kite or balloon. If there is enough wind, the kite should be used; if there is no wind, then the balloon may be used. The aerial should never be left up during a storm. There may be severe injuries to personnel as a result of lightning striking and traveling down the aerial.

To set up the transmitter for operation on water, remove the transmitter from the container; then remove the ground wire, unroll it, and drop it into the water. Remove the cotter key from the face of the container, and the aerial compartment will open. With the compartment door fully open, place the cotter key in the slot at the back of the door. This locks the door open. If the kite is being used, remove it from the container and assemble. Estimate the speed of the wind and secure the aerial to the kite either at the point marked

WINDS 7 TO 15 MILES PER HOUR or at the point marked WINDS 15 TO 40 MILES PER HOUR.

If the generator and balloon are being used, remove the top from the can containing the balloon. Insert the small end of the transfer unit into the neck of the balloon, making sure that the transfer unit is inserted fully into the neck of the balloon. Take the key supplied with the generator and remove the end of the generator marked TOP. Screw the threaded end of the transfer unit into the threaded depression in the center of the generator. Remove the bottom of the generator with the key supplied and, holding the handle of the transfer unit, insert the generator into the water until the water is even with the top of the generator. It might be necessary to shake the generator slightly to get water into the carbide to begin action. DO NOT SMOKE WHILE THE BALLOON IS BEING FILLED AS HYDROGEN IS EXPLOSIVE. It will take about thirty to forty minutes to get all the gas from the generator. When the unit stops generating, remove the transfer unit from the generator and throw the generator away. The residue is caustic and will cause burns. Attach the aerial to the balloon and pay out the aerial. Speed can be contolled by the brake on the drum. Turn the brake clockwise to tighten and counterclockwise to let the drum run free.

When the antenna is up, the operator should secure the transmitter by placing it between his legs, running the strap under his legs, and screwing it in the matching position on top.

The transmitter has a selector switch and three positions marked 8364 AND 500 KILOCYCLES, MANUAL, and LIGHT. By placing the selector switch at 8364–500 and turning the crank 80 to 100 r. p. m. an automatic SOS will be transmitted alternating 40 seconds on 8364 and 40 seconds on 500 kc. The probable daytime range of 8364 will be between 750 and 500 miles. The nighttime range may be increased greatly.

On 500 kc., when transmitting at sea under ideal conditions, the Gibson Girl has a range of 250 to 500 miles.

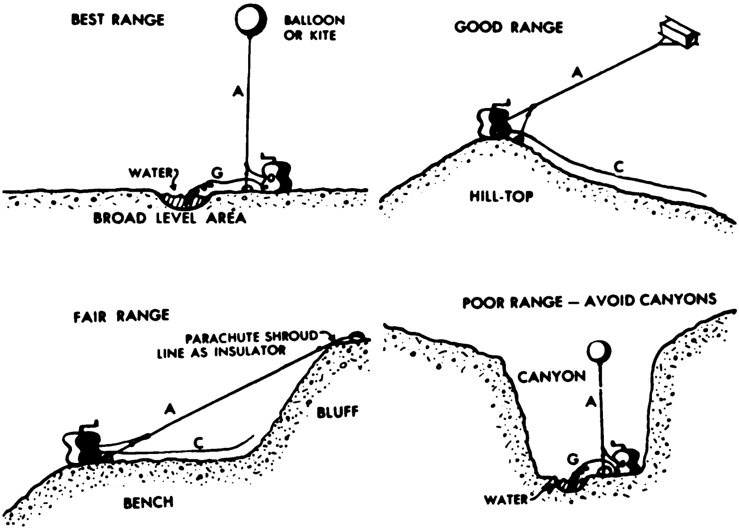


Figure 11-7.—Choice of terrain.

Transmitting on land, the range may be reduced to as much as 5 to 10 miles.

By placing the selector switch at the manual position, a message or steady tone can be transmitted by using the key on the left side of transmitter.

When the generator light is on, it indicates that maximum voltage (24–31V) has been reached, and it will do more harm than good to crank any faster. By plugging a signal light in the transmitter and turning the selector switch to LIGHT, a steady light can be obtained or a blinker can be sent by using the key.

The international distress frequency is 500 kc., and international law requires that all ships and stations maintain silence and guard this frequency for two three-minute periods during each hour, from 15 to 18 minutes past the hour and 45 to 48 minutes past the hour. These are excellent times for transmission.

If no lakes or rivers can be found to use as ground, a hole should be dug in the earth and the ground cable buried. Damp earth makes a good ground. The hole can be dampened by urinating in it and packing the earth around the ground cable. A good ground is important.

Caution: When the kit is dropped by parachute, the parachute static line should not be attached to any part of the body of the person dropping it.

Figures 11–7 and 11–8 illustrate the use of the transmitter.

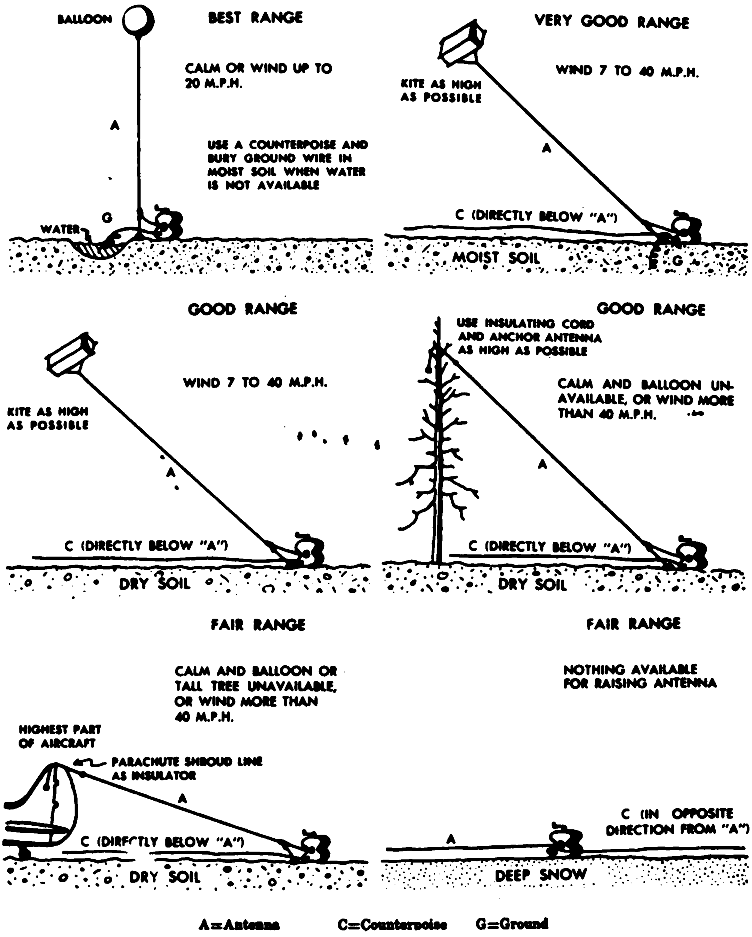

BALLOON
BEST RANGE
CALM OR WIND UP TO 20 M.P.H.
A
USE A COUNTERPOISE AND BURY GROUND WIRE IN MOIST SOIL WHEN WATER IS NOT AVAILABLE
G
WATER
VERY GOOD RANGE
KITE AS HIGH AS POSSIBLE
WIND 7 TO 40 M.P.H.
A
C (DIRECTLY BELOW "A")
MOIST SOIL
G
GOOD RANGE
KITE AS HIGH AS POSSIBLE
WIND 7 TO 40 M.P.H.
A
C (DIRECTLY BELOW "A")
DRY SOIL
GOOD RANGE
USE INSULATING CORD AND ANCHOR ANTENNA AS HIGH AS POSSIBLE
CALM AND BALLOON UNAVAILABLE, OR WIND MORE THAN 40 M.P.H.
A
C (DIRECTLY BELOW "A")
DRY SOIL
FAIR RANGE
CALM AND BALLOON OR TALL TREE UNAVAILABLE, OR WIND MORE THAN 40 M.P.H.
HIGHEST PART OF AIRCRAFT
PARACHUTE SHROUD LINE AS INSULATOR
A
C (DIRECTLY BELOW "A")
DRY SOIL
FAIR RANGE
NOTHING AVAILABLE FOR RAISING ANTENNA
C (IN OPPOSITE DIRECTION FROM "A")
A
DEEP SNOW
A=Antenna
C=Counterpoise
G=Ground

Figure 11–8.—Choice of setup.

TRANSCEIVER

(AN/PRC-17)

The transceiver was designed to be dropped to survivors behind enemy lines. It is used to communicate with covering rescue aircraft and to help direct helicopters in making a rescue pickup. However, the Navy is using it primarily to replace the radar reflector in pararafts and multiplace rafts.

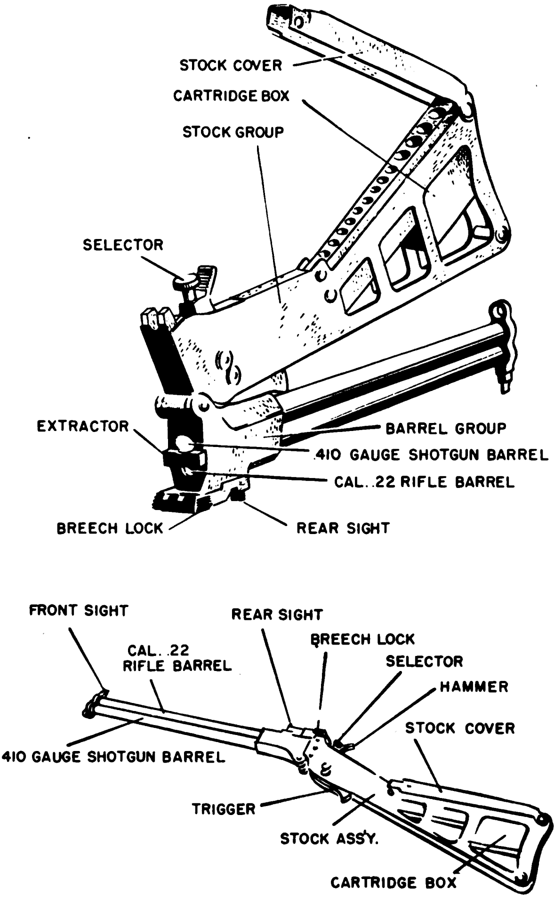


Figure 11-9.—M6 rifle/shotgun.

M6 RIFLE/SHOTGUN

The rifle/shotgun is included as an item in certain survival kits. It serves as a weapon for hunting various kinds of game. Figure 11–9 illustrates the gun in a partially folded and fully extended position.

QUIZ

1. The weight of the AR–4 lifeboat properly padded and protected for dropping is
   a. 124 pounds
   b. 110 pounds
   c. 95 pounds
   d. 85 pounds
2. The AR–4 lifeboat is dropped at or below
   a. 70 m. p. h.
   b. 80 m. p. h.
   c. 100 m. p. h.
   d. 115 m. p. h.
3. The bailing buckets are stowed in the
   a. port bow pocket
   b. starboard bow pocket
   c. oar pocket
   d. inside the container between the raft and container
4. The AR–4 lifeboat is equipped with
   a. weather shield
   b. rudder lock
   c. inflatable floor
   d. all the above
5. On the AR–4 lifeboat a wrench suitable for detaching the CO_2 cylinder is
   a. always attached adjacent to the cylinder
   b. never attached adjacent to the cylinder
   c. left up to the rigger's own opinion whether to put it in or not
   d. all of the above
6. The AR–4 lifeboat is
   a. not equipped to use a motor
   b. equipped to use a motor
   c. equipped to use a motor of high horsepower
   d. equipped to use an inboard motor

7. The carrying case of the AR–4 is closed with
    a. lift-the-dot snaps
    b. dura-dot snaps
    c. locking pin and cone
    d. snap fasteners and locking pin and cone
8. The AR–4 is designed to be dropped from
    a. an open hatch
    b. a bomb rack
    c. the R4D type aircraft
    d. all the above
9. The ADSK–1 was designed to be carried
    a. in the cockpit of fighter type aircraft
    b. inside transport aircraft
    c. on the bomb rack of fighter type aircraft
    d. on any type aircraft
10. The ADR–1 kit is designed to provide distressed personnel with
    a. rations for one week
    b. rations for 3 days
    c. rations for 8 days
    d. a maximum amount of water
11. When the ADR–1 kit is dropped, the indicated air speed of the aircraft should be between
    a. 85–100 knots
    b. 100–110 knots
    c. 110–125 knots
    d. 90–100 knots
12. The primary purpose of the AN/CRT–3 radio transmitter is to
    a. establish two-way communication between rescuer and survivor
    b. transmit distress signals
    c. establish communication by use of a signal light
    d. establish communication by use of Morse Code
13. Depending on atmospheric conditions, the range of the AN/CRT–3 is
    a. 1,000 miles
    b. 1,600 miles
    c. 2,000 miles
    d. 700 miles
14. The AN/CRT–3 radio transmitter is dropped at an altitude of
    a. 300 to 500 feet
    b. 600 to 800 feet
    c. 400 to 500 feet
    d. 500 to 700 feet

15. The wind velocities recommended for flying the kite with the AN/CRT–3 radio is
    a. 15 to 50 knots
    b. 20 to 50 knots
    c. 7 to 40 knots
    d. 10 to 25 knots

16. To operate an AN/CRT–3 radio correctly the crank should be turned at
    a. 50 r. p. m.
    b. 60 r. p. m.
    c. 70 r. p. m.
    d. 80 r. p. m.

17. The AN/CRT–3 alternates between 8364–500 kc.
    a. every 10 seconds
    b. every 40 seconds
    c. every 50 seconds
    d. every 15 seconds

18. What would happen if the crank on the AN/CRT–3 is turned faster after the indicator light is burning?
    a. An antenna would not be needed.
    b. A better signal would be sent.
    c. More harm than good would be done.
    d. More words per minute would be sent.

19. It is best to send a radio distress signal
    a. 5 to 8 minutes after the hour
    b. 15 to 18 minutes after the hour
    c. 40 to 43 minutes after the hour
    d. 48 to 51 minutes after the hour

20. The AR–4 lifeboat, when it is folded and rolled, is placed in the container with the open portion up and alined with the carrying case opening to
    a. make the pull handle end stick up out of the water
    b. make the life boat open correctly
    c. make the lifeboat float and inflate right side up
    d. keep the lifeboat from sinking

CHAPTER 12

PILOT'S PERSONAL AND RELATED EQUIPMENT

FLIGHT CLOTHING

Keeping pace with the demands of new developments, articles of clothing worn in flight are becoming more complex. The simple coveralls (light and heavy weight) are used daily in moderate speed and low altitude flying. However, the conditions experienced during high speed and high altitude flight have demanded more than a simple warm covering for the body. Consequently, the nature of flight clothing is progressing into a more overall protective stage which guards against sudden losses of cabin pressure and yet maintains an oxygen pressure range necessary to life. Besides protection from moderate to severe temperatures there are other more complicated elements and conditions to be considered. The attainment of recent higher speeds and higher altitudes have added greater problems to man's efforts to cope with the elements. To combat the danger of a sudden loss of cabin pressure (explosive decompression), and to extend the limit of high altitude flight, the doctors and engineers of medical research have developed a pressure suit.

The full pressure suit is designed to enclose the entire body completely. Its function is to reproduce automatically a normal environment. The correct percentages of oxygen and air combined with pressure and temperature control permits flights in the upper regions hitherto unattainable.

Classified as protective clothing and not flight clothing, the exposure suit is worn on all overwater flights in cold regions. The outer rubberized form of the suit, gripping snugly around the wrists and neck, prevents water from contacting the body. The head is the only exposed part. A quilted liner worn close to the body (or newly designed 2-piece winter flying suit) provides the necessary warmth. Without this suit, a man could not survive in water colder than 32° F. Designed for the protection of the head during flight, a football-like helmet offers more protection than the older model flight helmets which have been retained as liners for the later head models. The liners still support earphones and are also used to stabilize the outer shell (head helmet) through the application of webbing supports and snap fasteners.

A new 1-piece helmet is coming into general use. It incorporates built-in visor and electronics equipment.

This chapter is not designed to introduce all the available articles of flight clothing, but offers instructions on fitting and adjusting those items which need special attention in their initial servicing. The exposure suit, for example, must be individually fitted to the rubber boots. Particular attention must be given to the leg measurements in relation to the available material and the individual's freedom of movement. The protective helmet must be equipped for stability and be made adaptable to the oxygen mask. The anti-g suit might require zipper inserts in the legs to allow for expansion of the internal rubber bladders. To make the suit legs tighter for more effective operation, the leg seams can be taken in. In the initial fitting of clothes, the decisions revolve around the correct choice of fit which is that of selecting the proper size. However, everyone's measurements do not conform with standard size requirements. In naval aviation, it is the Parachute Rigger's job to make flight and protective clothing fit perfectly.

Occasionally, pilots and aircrewmen request that additional pockets or slings be incorporated in their flight clothing. However, the practice of arbitrarily affixing a sheath knife pocket to the trouser leg of a flight suit might later endanger a smooth and uninterrupted egression. In addition to the possibility of hampering an individual's movements during escape, the suspension lines of the opening parachute might foul in the sheath if it has not been attached properly. Whatever the requests for modifying flight clothing might be, there are four basic factors which must be considered: First, the weather and climatic conditions under which the article will be used; second, the fit of the clothing, since the comfort element depends not only on the type of clothing but also on the proper fitting; and third, appropriateness and safety of the modifications in relation to the purpose of the garment; and finally, the authority for the change.

Helmets

H–3 PROTECTIVE HELMET.—The protective helmet is worn in flight by pilots and aircrewmen of carrier type aircraft. It is constructed to absorb the impact and deflect the inertia generated by force. Inertia is the property of matter by which it will remain at rest, or in uniform motion in the same straight line unless acted upon by some external force. Therefore, when a man's head is thrown forward by the force of the crash, the helmet will tend to deflect this inertia or straight-line motion and slow it down, finally absorbing the force completely. Thus, the helmet gives protection to the head during a crash or buffeting. Buffeting, which is a series of violent vibrations, is experienced when passing through the sound barrier in supersonic flight.

A helmet has been the accepted item for head protection which dates back to the invention of the sword. The helmets first worn by aviators in open cockpits were designed to protect the head from wind turbulences created by the blast of propellers. They also aided in securing simple type goggles through loops, which were sewed to the sides and rear of the form-fitting garment. Since the development of jet aircraft, aviator's helmets have been made to resemble football helmets. The present-day design resulted in a headpiece which provides multiple protection simultaneously. The emphasis of protection has been placed on reducing the danger of concussion or unconsciousness in flight as well as in a crash, or during seat ejection.

The main differences between the H–3 protective helmet and modern day athletic and industrial types lie in the composition of the materials. The H–3 helmet is designed primarily to absorb the energy of impact rather than deflect it. As a result of a severe blow, the shape and material of the helmet will become partly crushed and broken. In becoming partially destroyed through impact, the helmet can absorb heavier blows than would be ordinarily possible had it been designed to remain intact. It is a simple matter to design a helmet that is extremely rigid, but such protection as this affords would be lost when the energy of a very heavy blow was transmitted. Something has to give, and the answer is reflected in the material used in a helmet's construction and the method of suspending it over the head. The force of impact must be transmitted evenly over that area and not be concentrated at one point.

The H–3 protective helmet assembly is composed of two parts, a cloth underhelmet or liner and a rigid protective shell which resembles a football helmet. The underhelmet was designed for use with the shell. As shown in figure 12–1 (A), the underhelmet fits the head snugly, extends well forward on the cheeks to protect the face from frostbite, and offers a purchase for the oxygen mask. Figure 12–1 (B) shows an inside view of the protective shell. The underhelmet, henceforth called liner, also carries the earphones which are imperative to communication.

The physical facts of construction are as follows:

1. The liner is available in five sizes: small (6⅝ to 6⅞); medium (7 to 7⅛); intermediate (7⅛ to 7¼); large (7¼ to 7⅜); extra large (7⅜ to 7⅝).

2. A strap and buckle are sewed on the back of the liner to provide a limited head-size adjustment.

3. The chinstrap is attached to both the liner and the outer shell.

4. The shell is furnished in four sizes: small (6⅝ to 6⅞); medium (7 to 7¼); large (7¼ to 7⅝); extra large (7⅜ to 7⅝).

5. The shell is fitted to the head by means of a sling suspension having an adjustable headband. (See fig. 12–1 (A) and (B).) Buckles for adjustment of the headband are

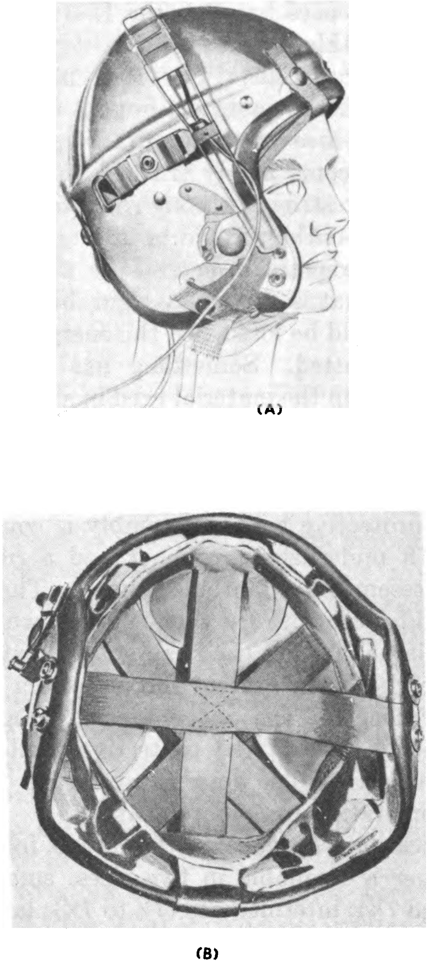


Figure 12-1.—The H-3 protective helmet. (A) Shell and liner; (B) inside view of shell.

located on both sides of the shell exterior just above the ear level. The most protection against impact is obtained when the headband is adjusted to fit snugly.

6. Additional protection against injury from impact is provided by padding within the shell, consisting of four pieces of Royalite (a synthetic cushioning material) cemented

directly to the shell interior, and small pieces of leather-covered foam rubber placed circumferentially between the adjustable headband and the shell. (See fig. 12–1.)

7. A male snap fastener is located on each side of the shell exterior between the two buckles for adjusting the headband and provides a means for attaching the flying goggles to the protective shell. (See fig. 12–1.)

8. A fitting is riveted to the RIGHT SIDE of the shell exterior for attaching a boom-microphone. (See fig. 12–1.)

Figure 12–2 illustrates the headgear equipped with stabilizer, straps, flying goggles, microphone, and oxygen mask.

The stabilizing straps and chinstrap were added to provide the additional stability needed when catapulting, when

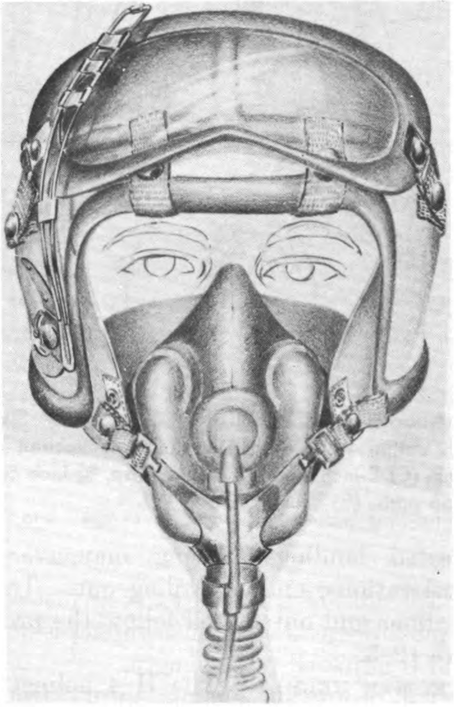


Figure 12–2.—Fully equipped helmet.

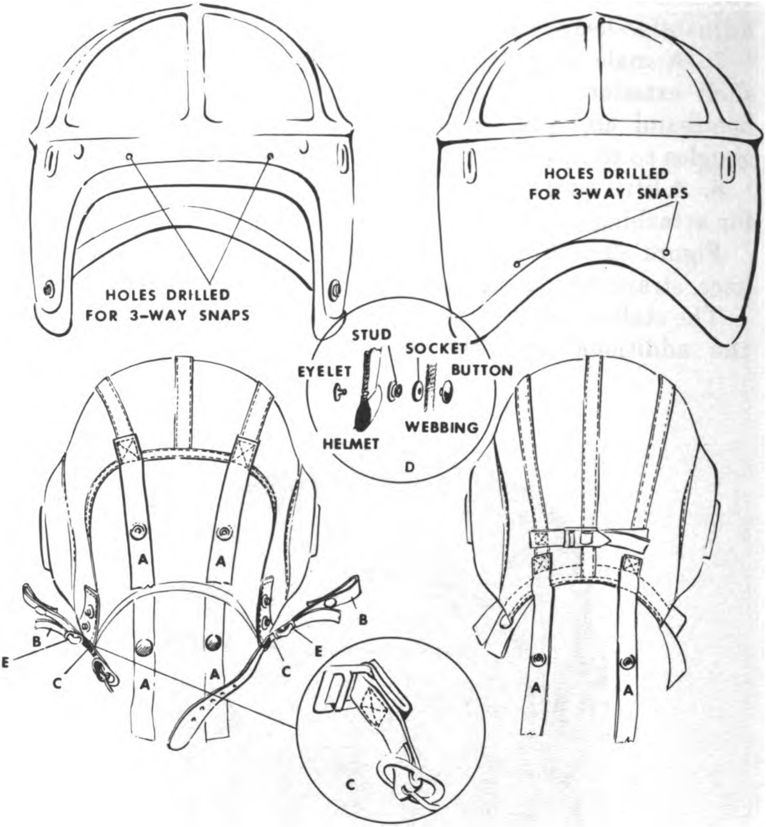


Figure 12–3.—Attachment of stabilizing straps. (A) Six-inch retainer straps, ¾-inch cotton webbing; (B) 5½-inch connection straps, ¾-inch cotton webbing; (C) 2-inch buckle retainer strap, ¾-inch cotton webbing; (D) 3-way snap parts; (E) buckles.

making arrested landings, during maneuvers involving high "g" accelerations, and in bailing out. To attach the straps to the liner and outer shell follow the procedure outlined in figure 12–3.

H–4 PROTECTIVE HELMET.—The H–4 helmet is basically the same as the H–3 with the following exceptions:

1. The headband is fixed in front and is not adjustable.

2. The front of the helmet has been lowered for increased protection and stability.

3. The center panel of the innerhelmet is made of nylon mesh for coolness.

The stability of the H–4 helmet is an improvement over the older type; however, the stabilizing straps omitted on the H–4 may be added when requested.

Summer and Winter Flight Suits

The summer flying suit is a lightweight 5-ounce cotton twill cloth, khaki, one-piece coverall type suit. It has a pocket on the sleeve for pencils and patch pockets on each knee for items of survival. The coveralls can be worn over the anti-g suit (antiblackout suit), but never in lieu of it, since the function of the anti-g suit is designed to prevent blood from leaving the upper parts of the body rather than for the purpose of covering the body. The summer suit is used more in the squadrons operating multiplace and/or multiengine aircraft. All garments of this kind should be treated with a fire-retardant compound for the protection of the pilot and crewmen.

For cold weather or extremely high altitude flights, a number of different winter type flight suits have been developed. The coverall type winter flying suit is made with a nylon cloth face, backed with wool, and lined with alpaca. It is equipped with four button-down flap pockets (two on the chest and two on the knees) and has a zipper front. This suit does not protect an individual who is submerged in cold water. Only the antiexposure suit offers this universal protection against cold air and water.

Flight clothing is indexed in class 37 of the *Aviation Supply Office Catalog*. Here, one can familiarize himself with dozens of items available for use. Not all articles follow the usual routine channels of issue. Some things are controlled. This control depends on the area of their usefulness, and the antiexposure suit is one of these items. Later, the exposure suit will be described in detail. Materials issued by the Supply Department and unit flight gear pools, such as flight suits, boots, goggles, and gloves, are held accountable. Therefore, every old or damaged item must be returned to stores before a replacement can be reissued.

Miscellaneous Smaller Items

In some squadrons, the task and accountability of small personal survival items such as pen lights, compasses, sheath knives, and signaling mirrors are given to the Parachute Rigger. In this case, he is held responsible for their distribution, and as a result, must maintain records. When a pilot leaves the squadron, he returns his life vest and other small items issued to him by the Parachute Rigger.

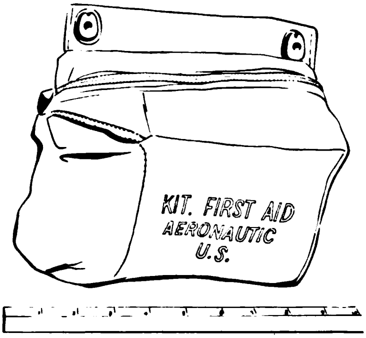


Figure 12–4.—First aid kit. ***Note:*** **Contents can change as directed by BuMed.**

First aid kit.—Whenever an airplane is accepted by a squadron, certain items of equipment are delivered with it. One of these items is a first aid kit. Since it is considered a survival article, the Parachute Rigger is responsible for inspecting its contents. Figure 12–4 illustrates the first aid kit which is carried in some accessible location of the cockpit or cabin. When an airplane is released by a squadron, the first aid kit is transferred with it.

ANTI-G EQUIPMENT

PURPOSE.—Anti-g equipment is currently installed in high performance aircraft to counteract the effects of prolonged acceleration on the pilot. The ill effects of such acceleration range from excessive fatigue and decreased alertness to blackout and unconsciousness.

EFFECTS OF ACCELERATION.—Though there is no limit to the speed a human being can endure in straight and level flight in an aircraft, changing speed or direction can lead to reactive forces of inertia to which the body has a sharply limited tolerance. In the case of extreme stresses exerted by acceleration of the type met in seat ejection, ditching, or parachute opening shock, the short duration of the acceleration restricts its effects. However, changing the direction of flight often produces prolonged radial acceleration (longer than a second) which can have dangerous effects.

It is generally stated in relation to g suits, that for each unit corresponding to the pull exerted by the earth's gravitational field the force of inertia in acceleration is proportional to the square of the velocity and inversely proportional to the radius of the turn. At 5 g's for example, the pilot's body is exposed to a force of inertia which increases its "weight" and that of its components five times.

This increased "weight" has many effects. The pilot is pushed down into his seat. His arms and legs feel like lead and manipulation of the controls becomes more difficult. In addition, the extra weight of the viscera (internal organs) causes abdominal and chest discomfort. Most important, however, is the effect on the circulatory system.

At 5 g's the pressure exerted by the column of blood between the head and the heart becomes just about equal to the blood pressure in the arteries. As a result, the pressure supplied by the heart is not great enough to pump an adequate supply of blood to the head. Experiments with relaxed subjects on a centrifuge show that the first symptoms of difficulty appear at 3.5 to 4.0 g's. These symptoms consist primarily of the graying of the visual fields. At slightly higher accelerations, 4.0 to 4.5 g's, blackout occurs. Though the individual retains consciousness, he cannot see. At 4.5 to 5.0 g's he loses consciousness. By straining maneuvers and other conscious efforts, a pilot in an aircraft can increase his tolerance somewhat. However, if acceleration is significantly greater, these effects still occur.

To counteract these effects, the arterial pressure must be increased above the heart level. At the same time distended vessels and tissue and fluid spaces in the regions below the heart must be restored to normal. This is accomplished by the anti-g suit. With the anti-g system, compressed air is metered to the suit in proportion to the acceleration, and the suit compresses the legs and abdomen of the wearer by an amount proportional to the acceleration. Thus, the suit prevents venous pooling in the abdomen and lower extremities and forces blood from the lower to the upper part of the body. This effect increases venous return to the heart and increases resistance to the shifting of blood to the lower limbs. In addition, it causes the diaphragm to be raised and thus decreases the distance between the heart and the eyes and/or the brain. Altogether, it increases the tolerance of the pilot an average of about 2 g's.

TEST RESULTS.—Without an anti-g suit, the average pilot can withstand 4.5 to 5.5 g's without losing vision or blacking out. With a suit, he is capable of withstanding 6.0 to 7.0 g's. However, this protection is available only for sustained accelerations of 4 to 5 seconds or longer in maneuvers other than snap maneuvers. Anti-g equipment does not offer protection in snap maneuvers where 10 to 12 g's can be applied in approximately one second. Such brief forces are not as harmful to the body as lesser forces which are sustained for a number of seconds.

DESCRIPTION.—The anti-g suit is a coverall of nylon construction which is worn as the only article of outside clothing in warm climates. Its exterior resembles the summer flying suit. Its total weight, including the five plastic coated nylon bladders with connective tubing, is approximately three pounds. (See fig. 12–5.)

The bladders and tubing of the present suit are also made of nylon, but are impregnated and coated with vinyl resin.

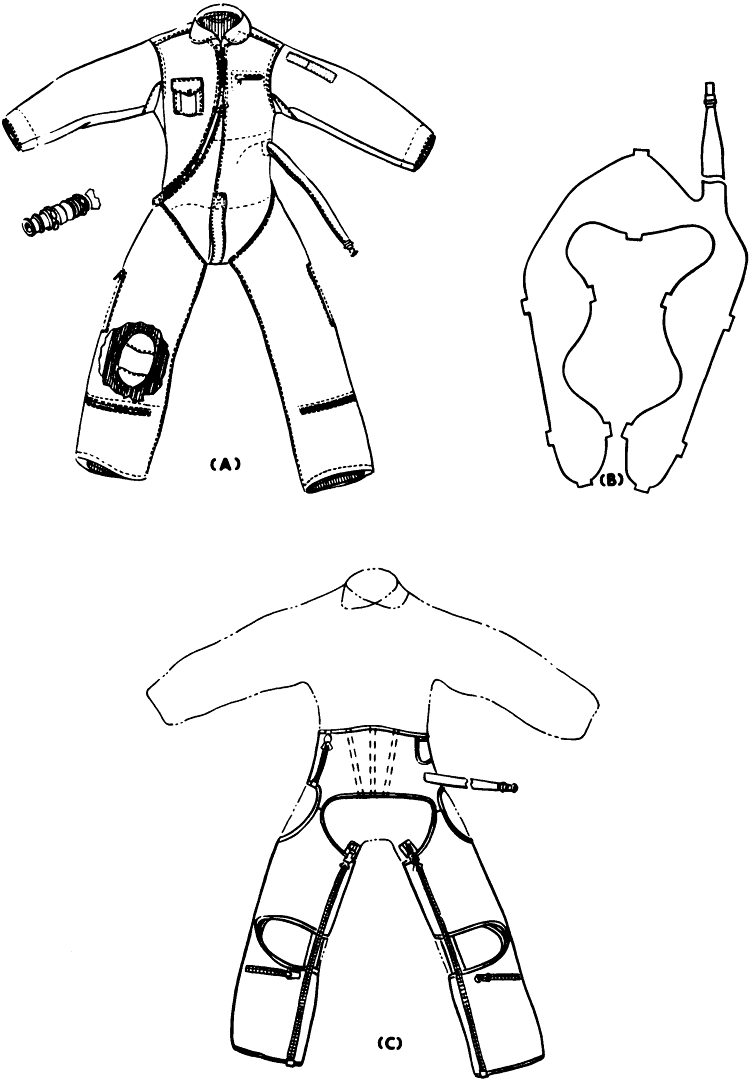


Figure 12–5.—Anti-g suits. (A) Z–2 coverall type (front view); (B) internal bladder arrangement; (C) Z–3 cutaway type (front view).

A coiled wire covered with a nylon screen to prevent abrasion is placed inside the bladders and tubing to keep the bladders from collapsing. There is no rubber in the bladders or tubes. The bladder system is connected on the left side of the suit to a tube which is fitted with a metal male plug. This plugs into the quick-disconnect of the console which is mounted on the left side of the seat in most aircraft.

Placed in the left breast pocket of the suit is a valve which can be inserted into the mouth of the suit's inflation tube. By inserting the valve in the tube, and blowing air into the bladders, the suit can become a secondary means of byoyancy in conjunction with or in lieu of the life vest. Before this is done, the legs should be unzipped by the quick release zippers on the upper thighs and snapped together in the back. The anti-g suit was not designed to replace the life jacket in emergencies, but it can be used as a means of secondary flotation. The Z–2 suits are available in sizes ranging from 36 to 44 in long, medium, and short lengths. The Z–3 suits, which are more adjustable, are available in large and small sizes, in short and long lengths.

REGULATING VALVES.—There are two types of anti-g regulating valves currently in use. They are distinguished by a regulating valve (NAF 1233) which is installed in reciprocating engine aircraft in which anti-g equipment is available. The air source comes from the positive pressure side of the vacuum pump. The valve is automatically actuated after 1.75 g's is attained and 1.0 p. s. i. per g is regulated to the anti-g suit. No valve selective features are available to the pilot.

Type JP–9 anti-g valve (NAF 1237) is a later design and is installed in jet type aircraft. (See fig. 12–6.) In contrast to the type NAF 1233 valve, this valve makes possible a selection of either a high or a low suit inflation pressure. At the LO setting, the suit is inflated with 1.0 p. s. i. per g. At the HI setting, the suit has an inflation pressure of 1.5 p. s. i. per g. Another feature of the JP–9 valve is the pushbutton at the top which may be operated manually to test the anti-g equipment on the ground or in level flight. Prior to each flight, the pilot should depress this button to

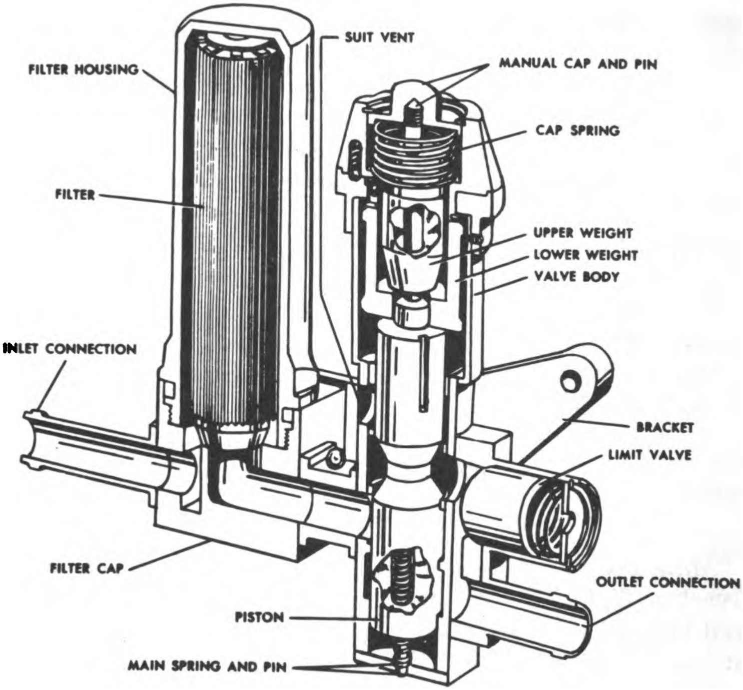


Figure 12–6.—JP–9 anti-g valve.

check the operation of the system. This feature also makes possible the inflating of the suit in long flights from time to time in order to relieve venous congestion of the legs and stiffness and tension of the body by a massaging effect of the inflating bladders.

The JP–9 valve is also actuated automatically at 1.75 g's. The valve receives air under pressure from the compressor of the turbojet engine. It is equipped with a safety valve to prevent excessive pressure from reaching the suits.

How to use it.—The suit should fit snugly especially at the waist. The Flight Surgeon, often aided by a Parachute Rigger, instructs and fits personnel. If there is any doubt about the fit, the pilot should sit in the same position as in the plane and inflate the suit orally. The bladders should compress at the waist, calves, and thighs, firmly and evenly.

Should difficulty be encountered in properly fitting legs, zipper inserts are available to increase the leg sizes. A snug fit means better protection and more comfort under g forces.

Maintenance.—If necessary, the Parachute Rigger can decrease or increase the size of the calf or thigh. To inspect for leaks, tears, or weakened fabric, the suit should be inflated to 5 pounds per square inch. The pressure should not fall below 4 pounds in 30 seconds. When not worn, the suit should be hung on a coat hanger. It should be laundered in lukewarm water, washed by hand, and never scrubbed or ironed. Water should never be allowed to get in the bladders. When repairing tears, be careful not to sew through the bladders.

EXPOSURE SUITS

Constant Wear Antiexposure Mk 4

Antiexposure suits are designed to be worn on cold weather flights by all personnel. They provide warmth and buoyancy in case of emergency bail out or crash landing at sea. They are more effective on land than they are in the water, but without their protection from cold temperatures and near freezing water the individual would freeze to death quickly. A suit and liner have given protection from exposure for 2 hours in water at 28° F. In subzero weather on land, a suit will give protection for extended periods of time.

Antiexposure suits offer a positive means of buoyancy because of air being inside them. Only when full of water will the suit reach zero buoyancy. For greater ease in swimming, one should get into an upright position and release the entrapped air by pulling the neck seal away from its seat. The life vest need not be inflated unless the suit is torn and filling with water.

Components.—The complete antiexposure suit consists of four major components: An outer garment, an insulation liner, insulated gloves, and a g-suit hose covering. The cloth of the outer garment is made from a high strength cotton twill which is treated with a water repellant and a fire retardant prior to being coated on one side with a neoprene base compound. When the suit is assembled, the coated side is on the inside of the suit. The suit's wrist and neck seals are fabricated with an elastomer (an elastic rubberlike substance, of natural or synthetic rubber) supported by a network of 100 denier knit nylon yarn. A quilted material consisting of a layer of wool acetate batting, sandwiched between two layers of preshrunk rayon cloth, is used in the liner; a knitted fabric is used in such places as the armpits, wrists, ankles, collar, and g-suit aperture. The 2-piece winter flying suit can also be used in lieu of the quilted liner. The outer shell material of the gloves is coated; the fabric side is left exposed. An intermediate layer, designed to give warmth, is constructed from a knitted nylon fleece, and the inner shell is made from the same material as the outer shell. Molded rubber forms the hose covering.

The outer suit fabric is permeable to moisture and vapor, but will not admit water. Pockets for gloves and equipment are attached, and the entry and relief openings are equipped with a rolled-type seal and slide fasteners. The boots, attached to the outer suit are designed with sealed air chambers for cold protection, and are worn with light or medium weight socks. When the trapped air in the chambers of the boots expands at a high altitude and causes pressure, the air can be vented by actuating a valve on each boot to relieve the pressure. The boots are attached by Parachute Riggers and are furnished in whole sizes from 6 through 13, widths D and EE. A parka hood, five-finger flying gloves, and a watertight anti-g suit adapter, which is inserted in the end of the hose, comprise the additional items available for use with the suit. (See fig. 12–7.)

WEARING THE ANTIEXPOSURE SUIT.—For full protection and benefit from the suit, the following items of clothing should be worn in addition to the liner and outer garment: Heavy woolen underwear, anti-g suit (if needed), and a pair of socks. When the g-suit is worn, it must be passed through the openings provided in the liner and outer section. A rubber covering is then passed over the hose, one end being extended over the g-suit aperture, while the other end (elastic-like) grips around the outer extremity of the hose near the adapter.

Before putting the suit on, powder the hands and wrists with talc. Talcing rubberized surfaces prevents the skin area, in passing through the garment, from binding and possibly tearing the wristlets. Entrance is made by spreading the suit front and passing the legs through the entry opening. The g-suit hose is passed through the left side of the suit. Insert arms in sleeves by putting on the left side of the suit first and then the right side. Grasp the neck seal in both hands, spread it apart, and pull the seal over the head. Do not permit the seal to bunch up. It must grip snugly without wrinkles. The same holds true for the wrist seals. ***Caution:*** When inserting the feet into the boots, pull on the boots—not on the leg fabric. The entry canopy, by comparison, is more fragile than the material of the outer suit; therefore, upon entry, do not pull on the canopy. The Mk 4 suit closure is similar to that of the Mk 3 (some of which still remain in service) except that the flap is secured with two slide fasteners. This flap is closed by first zipping the lower fastener and then the upper one.

GENERAL CEMENTING INSTRUCTIONS.—A well-ventilated working area should be used to permit the adhesive to dry adequately and rapidly. To obtain watertight integrity of the suit, it is always necessary to observe the following rules:

1. Whenever cement is applied to a FABRIC SURFACE, three coats must be applied, allowing each coat to dry a half hour before applying the next.
2. Whenever cement is applied to a RUBBERIZED SURFACE, two coats must be applied allowing a half hour between coats. The cement may be used as long as it wets the surface or is brushable.
3. NEVER SKIMP ON COATS. The minimum number is set forth in repair and other instructions, follow them implicitly. If the correct number of coats are not used, adequate sealing is never accomplished and the effectiveness of the suit is materially decreased.

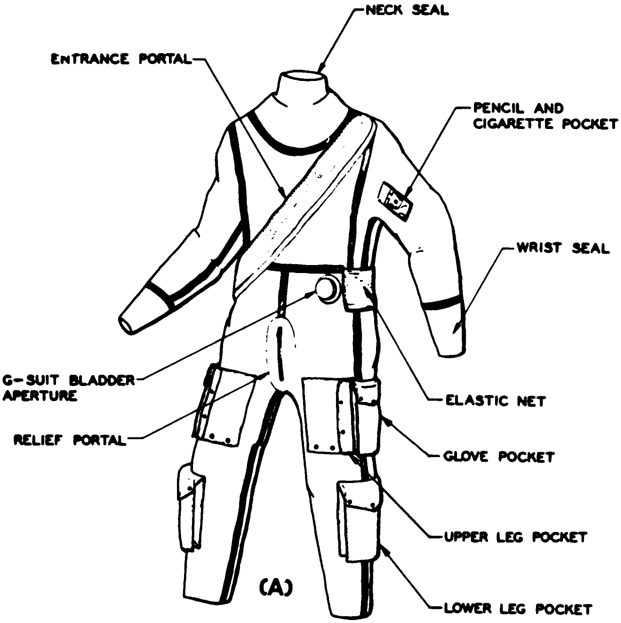


Figure 12-7.—Mk 4 constant wear antiexposure suit. (A) Outer garment—front view.

4. Never join two wet surfaces. Always wait until both surfaces become tacky before placing them together.

5. Always roll finished seams or joints with a slow heavy pressure. Unless rolled properly, adequate adhesion is never obtained between the two surfaces.

6. Whenever separating two surfaces that have been cemented, even for an instant, brush ethyl acetate into the area to be separated.

7. When making repairs on the interior of a suit and upon finding it necessary to work on some other section before the cement extending beyond a closed seam or an applied patch has had a chance to dry thoroughly, powder the area with talc. This will prevent the area from sticking to other parts. ***Caution:*** Make certain that talc does not come in contact with areas in need of further repair. TALC WILL NOT TAKE ADHESION. However, should this occur accidentally, dampen

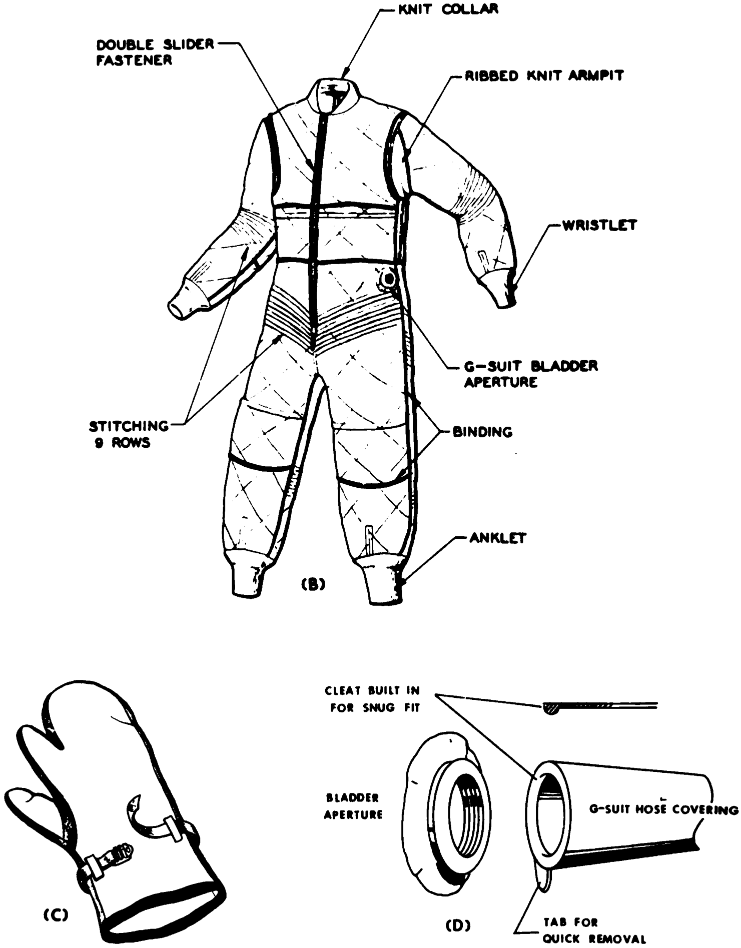


Figure 12-7—Mk 4 constant wear antiexposure suit—Continued. (B) insulation liner—front view; (C) insulated glove—right hand interchangeable; (D) g-suit hose covering and aperture.

a cloth with ethyl acetate and clean the affected area. Allow it to dry thoroughly before applying more adhesive.

NECK AND WRIST SEALS.—Each man issued the constant wear antiexposure suit must have the wrist and neck seals of the outer suit fitted by a Parachute Rigger. The instructions for fitting follow:

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1. Measure in inches the circumference of the NECK and WRISTS of the man who is to wear the suit.

2. Subtract 2½ inches from each measurement and divide the result by 2. For example, a 15½-inch neck minus 2½ inches equal 13 inches. Dividing 13 inches by 2 results in a value of 6½ inches. Now lay the suit out flat so that the top edges of the neck seal meet. Keeping the 6½ inches in mind and measuring along a line at the top of the seal which is at a right angle to the centerline of the suit mark off the measurement. (See fig. 12–8.) In applying this measurement, take care to center it, having 3¼ inches on either side of the centerline.

3. Keeping the neck seal flat with its edges matched, prepare to make the cut. Starting from left to right or from right to left, whichever side is most convenient, cut along a curved line (dipping below the straight line just marked) and follow the curve of the original edge of the seal. (See fig. 12–8.) Use the appropriate size scissors, which must be sharp to avoid nicking. When cutting, take precautions to prevent the bottom edge from slipping away from the line of cut. Any simple clamping device will hold the edges together firmly. As for measuring and marking the wrist seals, be guided by the centerlines of the sleeves and the original edge line.

FITTING AND ATTACHING BOOTS.—The fitting instructions are as follows:

1. Have the person to be fitted extend his arms over his head while wearing the liner and outer suit. Raise the right leg and bend the knee until the thigh is at right angles to the body. Placing the boot next to the left leg, make a mark at a point 2½ inches below the top edge of the boot. (See fig. 12–9.) Repeat the procedure on the other leg.

By having the individual raise his leg and extend his arms causes the suit leg to be drawn up on the standing leg as much as possible. To this has been added another 2½ inches for cementing the end of each suit-leg to its respective boot.

At this point, too much emphasis cannot be placed on the importance of allowing enough slack in the legs of the suit.

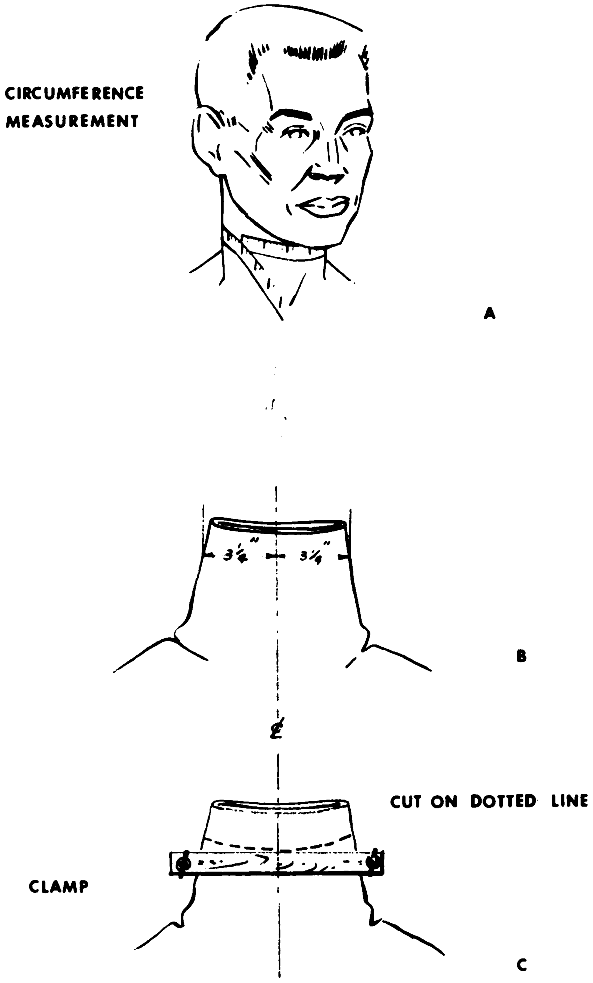


Figure 12–8.—Steps in marking and cutting neck seal.

An insufficient measurement will lead to restricted movements; the restricted movements, will strain the material and seams and will damage the suit. IT IS BETTER TO HAVE TOO MUCH SLACK THAN NOT ENOUGH. With the suit off, place a 5½-inch diameter cylinder in a leg deep enough so

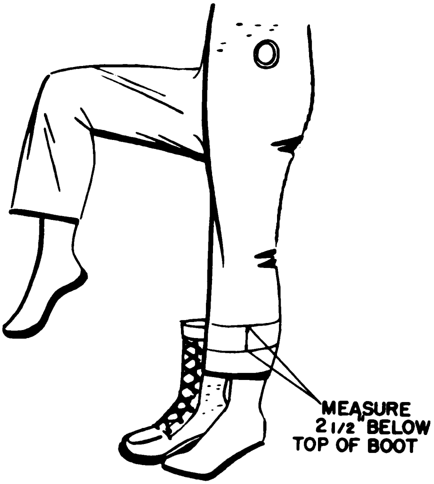


Figure 12–9.—Fitting the boot.

that the bottom edge coincides with the mark just made during the stretch. Complete the cutting mark around the leg, using the bottom edge of the cylinder as a guide. Do not make a lopsided mark. If the mark on the inside of the leg is lower than that on the outside, the boot may be cemented to the suit leg at a rakish angle. This can be avoided in the beginning by the application of a number of commonsense methods. During the stretching period of the fitting, mark the inside of the leg as well as the outside, using the boot edge as a reference. If an inside leg mark was not made during the fitting, and rather than have the man put the suit on for a second time, measure up from the bottom edge of the leg the same distance as the outside mark indicates to obtain a straight cutting line. However, if the bottom edge of the leg in question is not in an even condition (lopsided in the beginning), the suit will have to be put on again, and an inside leg mark be made relative to the top edge of the boot.

2. Cut off the excess material from each leg.

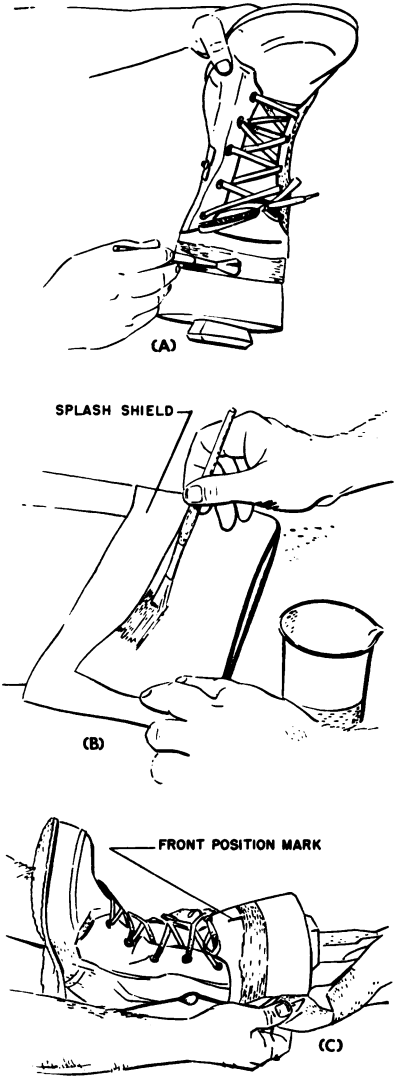


Figure 12–10.—Steps in attaching the boot.

3. Insert a tapered block in the top of each boot, tapered end down, until a snug fit is obtained.

4. Coat the upper 1½-inch portion of the boot exterior with adhesive. (See fig. 12–10 (A).) When dry, apply a second coat, making certain no adhesive is allowed to remain on the blocks.

5. Make a 3½-inch temporary cuff on the suit leg, and apply a coat of adhesive on the RUBBER SIDE for a distance of 1½ inches from the bottom. (See fig. 12–10 (B).)

6. When the adhesive on the boot and suit leg is dry, apply a third coat on the boot top and a second coat to the suit leg.

7. While the final coat of adhesive is still tacky (approximately 8 to 10 minutes) attach the suit leg to the boot so that a 1½-inch lap joint results. (See fig. 12–10 (C).) ***Caution:*** BE CERTAIN TO ATTACH THE RIGHT BOOT TO THE RIGHT LEG AND THE LEFT BOOT TO THE LEFT LEG. Use reference marks in aligning the boots (centerline of boots—front and rear with centerline of the suit legs—front and rear). All edges should be closed, pressed together, and rolled firmly with a roller. Make certain that there are no wrinkles or channels in the material during the attachment.

8. Apply a coat of adhesive to the fabric surface to that portion of the side seam which is to be overlapped as shown in figure 12–11 (A). When this coat becomes dry, apply a second coat. At the same time, coat the rubber side of that portion of the side seam that overlaps. (See fig. 12–11 (B).) After approximately a half hour, coat both surfaces again. When these become tacky, join the side seam and roll firmly, backing the seam with the hand. Make certain that there are no wrinkles or channels in the material of the seam.

9. Apply a coat of adhesive to all untapered seams. Apply a second coat to the side seam after the first has dried. When the side seam has dried for the second time, apply a third coat. When the adhesive on the side seam becomes tacky, remove the holland cloth from the bias tape. Apply the tape to this seam, cutting off the excess amount at the bottom edge of the lap joint running around the boot.

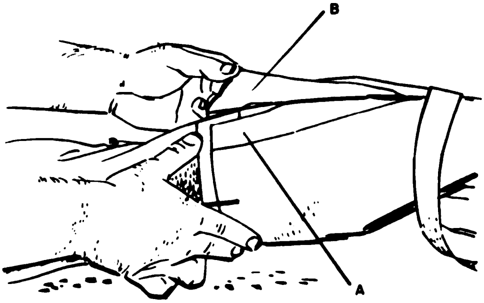


Figure 12-11.—Steps in closing the side seam.

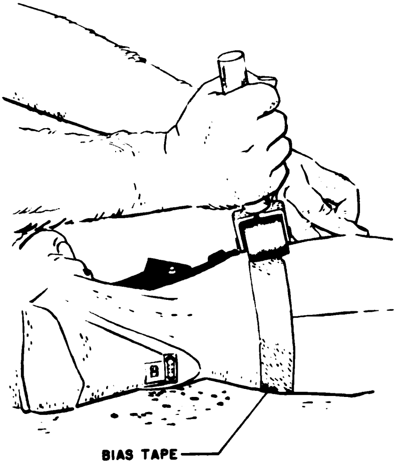


Figure 12-12.—Finishing the boot.

10. Apply the second coat to the circumferential (around the boots) lap joints, and allow to dry. Apply a third coat of adhesive to only one lap joint. When this becomes tacky, apply the tape, removing the Holland cloth. Overlap the end of the tape at least ¾ of an inch. Use the roller to make a smooth tight finish. Now apply the third and final coat to the circumferential joint of the other boot.

When this coat becomes tacky, tape and roll firmly. (See fig. 12–12.) Remove the wooden blocks.

11. Allow one day for the final curing of the neoprene liquid cement.

CARE AND MAINTENANCE.—When not in use, the suit should be kept on a hanger in a cool and well-ventilated place. Never store it in the direct rays of sunlight. Inspect the suit at frequent intervals for damage, especially in the non-fabric areas. Repair materials are provided in the special repair kits.

In repairing minor holes or tears in the outer suits, obtain the suit fabric and cement from the repair kits. Clean the area to be patched and the rubberized side of the patch with solvent (ethyl acetate or naphtha). After the solvent has evaporated, apply an even coat of adhesive to the surfaces. Allow it ti dry and then apply another coat. When this coat has dired, apply the third coat and wait until it becomes tacky. Then affix the patch, pressing it down and rolling it firmly. Do not attempt to make major repairs, such as the replacement of a section. When a suit is severely damaged, obtain a new suit in exchange.

Suit liners can be dry cleaned; however, when such a method is not available, a "hand-wet-cleaning" procedure may be undertaken. This procedure consists of the following steps:

1. Dip the garment in a tub of water (90° F.) to which has been added any neutral synthetic detergent in the proportion of one teaspoon full per gallon of water.

2. Gently SQUEEZE OUT excess cleaning solution. (Do not wring it out.)

3. Place the liner on a flat table or surface and rub with a cellulose sponge or soft bristle brush until clean.

4. Rinse in a tub of cold water.

5. Gently squeeze out excess water.

6. Hang on a wooden hanger so the liner is suspended by the shoulders and let it dry thoroughly. Do not spin-dry it in a machine. Never dry the liner with a heating device.

7. Do not iron or press.

With time and progress, new model antiexposure suits will appear in service. The Mk 4 suit was chosen as an example merely to establish a reasonable pattern for the care and maintenance of any similar garment. However, the Parachute Rigger, realizing the importance of a specific manner for performing a particular job, must not accept the procedures just outlined as being universally applicable for all past and future type antiexposure suits. Keep up-to-date with technical publications.

Quick-Donning Antiexposure Suit

The Mk 1 and R–1 antiexposure suits are similar in design and construction and provide equal protection against cold water. These suits are constructed of a lightweight waterproof material, and are designed to be put on easily and quickly before landings at sea. A suit consists of a single-piece coverall type garment with attached hood which envelops the body. The face is the only part left uncovered. Mittens are stored in the pockets to provide protection for the hands. The suits are all the same size, and are packaged or folded in convenient carrying pouches for easy stowage in aircraft. (See fig. 12–13.)

USE OF THE SUIT.—A technical publication lists the areas of the globe where the quick-donning suit should be made available for use.

When it is necessary to abandon an aircraft while over water, the quick-donning exposure suit should be put on over the flying clothes, but under the life vest and parachute harness.

The hood of the suit is made with a sufficient fullness so that it can be worn over the headgear. Use of the hood is optional, as the suit is watertight whether the hood is worn over the head or left folded under the neck closure.

The mittens are normally worn after boarding the life raft. They will provide protection against the cold even though wet.

WEARING INSTRUCTIONS.—Follow the steps listed below which outline the procedures for donning the suit:

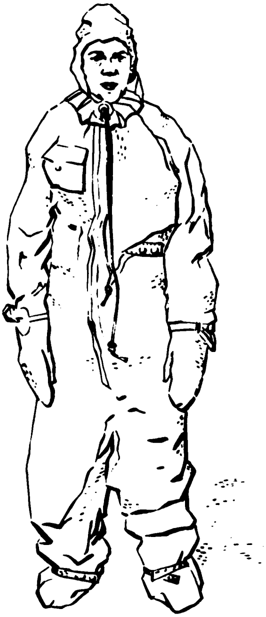


Figure 12-13.—Quick-donning Antiexposure Suit Mk 1.

1. Exercise caution when putting on the suit. Do not damage it by snagging, tearing, or puncturing.

2. Remove the suit from the container and unroll.

3. Grasp it by the neck and put the feet into the boots. Then pull the suit on over the shoulders while extending each arm, in turn, through the sleeve openings.

4. Pull the hood over the head.

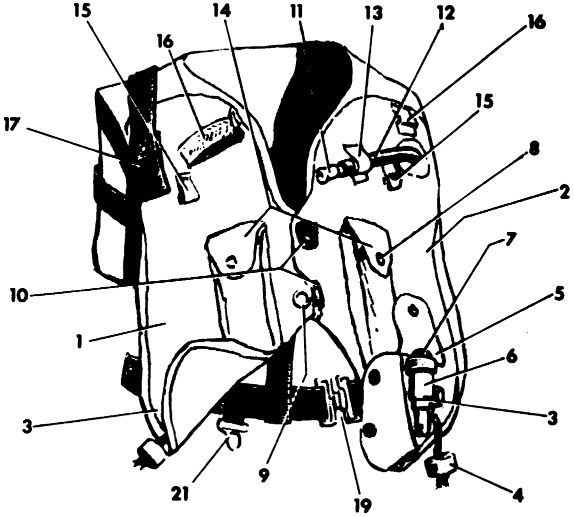
5. Pucker the suit tightly around the neck by grasping the small beads on the drawstring and pulling the slide lock up to within about six inches of the neck.

6. Adjust ankle straps so that the legs will not sag.

7. After both leg straps are adjusted, the greater portions of the entrapped air should be vented out through the neck opening, then the drawstring slide lock should be pulled up securely against the wearer's neck.

8. Undergarments protruding between the neck and neck closure will prevent a watertight seal. The neck closure is

Front view



Back view

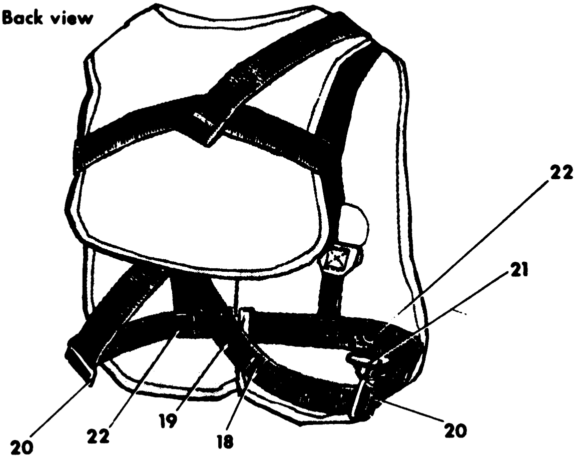


Figure 12–14.—Mk 2 life vest.

not uncomfortable when adjusted properly and it will make an almost airtight seal when the underclothing is kept out of the way.

9. When contacting the water, jump in feet first with the arms close to the sides of the body or held together over the head.

Inspection.—To prolong the life of the suit and maintain its reliability, inspect each garment prior to issue and every 60 days thereafter. The inspection rules follow:

1. Inspect for cracks, tears, holes, and seam separation; defective snap fasteners, buckles, webbings; and deterioration from foreign substances.
2. Make all inspections on a smooth surface, free from harmful agents.
3. Defective suits are returned for repair to overhaul activities.

MK 2 LIFE VEST

Design and Construction

The pneumatic Mk 2 life vest was designed to be comfortable when worn in flight. To accomplish this, it is worn in its deflated state which permits the wearer all the freedom of movement necessary for the performance of his duty. When inflated, the vest must give adequate and properly distributed buoyancy. Fully inflated, the vest will support a minimum buoyancy of 30 pounds. An important feature of the vest's supporting qualities is that its neck portion maintains the

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Nomenclature for Figure 12–14.

1. **Right lobe.**
2. **Left lobe.**
3. **CO_2 holders.**
4. **CO_2 holder lanyard.**
5. **CO_2 holder cover.**
6. **CO_2 cylinder (8-gram capacity).**
7. **CO_2 holder cap and gasket.**
8. **Flathead type snaps.**
9. **Lobe grommets.**
10. **Lobe fasteners (large curtain type covered).**
11. **Oral inflation valve.**
12. **Oral inflation tube.**
13. **Oral inflation tube connector loops.**
14. **Distress signal pockets.**
15. **Dye marker tabs.**
16. **Vest light loops.**
17. **Hoisting strap.**
18. **Body harness.**
19. **Harness fasteners.**
20. **Adjusters.**
21. **Pararaft retainer fitting (blanket loop).**
22. **Snap fasteners.**

wearer's head above the surface while the harness suspends him vertically in the water. Since the vest is self righting when properly worn and adjusted, it will always float the wearer in the safest position with his head out of the water. As a further aid to rescue, small tabs and pockets are fashioned to the vest's front lobes for holding signaling equipment.

The body of the vest is fabricated from neoprene coated nylon fabric. The vest is made in three independent compartments. The inside and outside compartments are inflated by carbon dioxide gas, and the middle compartment is inflated orally through an oral inflation valve and tube. Deflation of the CO_2 compartments can be accomplished only by removing the CO_2 inflator caps. The air compartment is deflated by depressing the oral inflation valve. A nylon webbing harness, complete with adjusting and fastening devices, maintains the vest in position on the wearer's body. Study figure 12–14.

BUOYANCY.—When the two CO_2 compartments are inflated (from the standard 8-gram cylinders), the buoyant force (lift) of the vest is 20 pounds. If the center air compartment is also inflated (blown up by mouth), the buoyant force is increased to 30 pounds. This means, in effect, your weight in the water is less than its weight in air by an amount equal to 30 pounds plus the buoyant force of the water. Since the body, in water, weighs a negligible amount in comparison to its weight in the air, 20 or 30 pounds buoyancy is all that is needed to float it successfully. It is interesting to note that inflation of the air cell alone will also produce a 30-pound buoyant effect. A vest capable of floating a 30-pound steel weight in fresh water is inflated to a pressure of 1½ p. s. i. This, then, is the maximum pressure necessary for the vest to sustain in order for it to pass the buoyancy test successfully.

DESCRIPTION OF MAJOR COMPONENTS.—A brief description of the major components follows:

1. ORAL INFLATOR: The oral inflation valve is a self-closing type and is operated by a spring. It can be locked

closed by turning a collar until it bears against the depressible valve body.

2. Body harness: The body harness is easily adjusted to fit all personnel. Its hoisting strap, which is part of the harness, can be used as an auxiliary hoisting sling for helicopter rescue purposes.

3. Dye marker tabs: Two tabs, one on the front of each lobe, are provided for attaching dye markers and a shark chaser packet.

4. Vest light loops: A loop is located on the upper right lobe of the vest for stowing the one-cell life preserver light prior to use. An additional loop is located on the upper left lobe for attachment of the light after the vest has been inflated.

5. Oral inflation connector loop: This is a loop, on

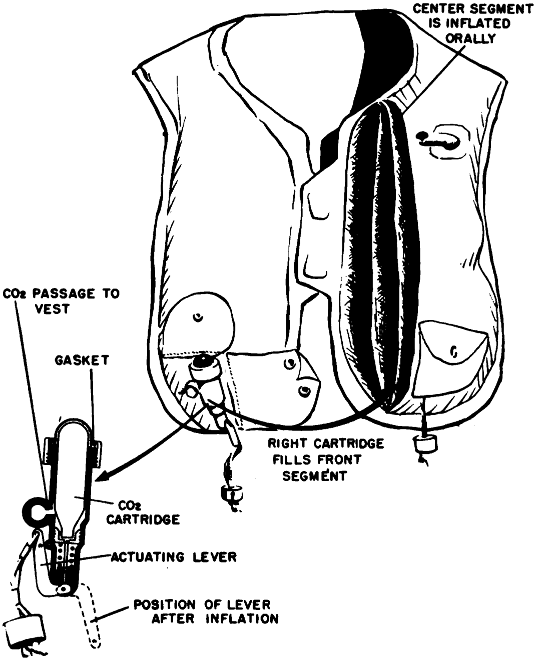
CENTER SEGMENT IS INFLATED ORALLY
CO_2 PASSAGE TO VEST
GASKET
RIGHT CARTRIDGE FILLS FRONT SEGMENT
CO_2 CARTRIDGE
ACTUATING LEVER
POSITION OF LEVER AFTER INFLATION

Figure 12–15.—Operation principles of the CO_2 holder.

the left lobe, used to prevent excessive movement of the oral inflation connector tube.

6. EQUIPMENT POCKETS: Two pockets, one on each lobe, are used for carrying Mk 13 distress signals and a whistle.

7. CO_2 INFLATOR COVERS: These are flaps used to cover the CO_2 inflators on each lobe of the vest. They prevent the actuating lanyards and the holders from catching on projections.

8. PARARAFT RETAINER FITTING: This fitting is incorporated in the waist strap of the harness for attachment of the snap fitting of either the pararaft or multiplace life raft retainer lanyards.

9. SNAP FASTENER STUD: A stud located under each lobe of the vest to mate with the fastener components on the harness. They prevent upward movement of the lobes when the vest is worn deflated. When the vest is inflated, the fasteners separate and release the vest lobes permitting them to assume their most effective buoyant positions.

OPERATION OF THE CO_2 HOLDER.—The operation of the CO_2 holder is illustrated in figure 12–15.

Accessories

The survival equipment secured to the life vest is shown in figure 12–16. Use a square knot in tying dye markers and shark chaser packets to the tabs provided. The single cell light is normally stowed and carried in a loop on the right lobe during flight. After entering the water, the light should be transferred to the loop on the left shoulder. The sharp point of the pin on the light must be blunted and smoothed off BEFORE INSTALLATION to prevent puncturing the vest material.

Fitting the Vest

All life vests should be individually fitted to allow enough slack in the harness so it will not bind the wearer after inflation. The simple fitting procedure is as follows:

1. Have the wearer put on the vest and secure the harness link fastener, the fasteners which join the lobes, and the fasteners which hold the lobes to the waist belt.

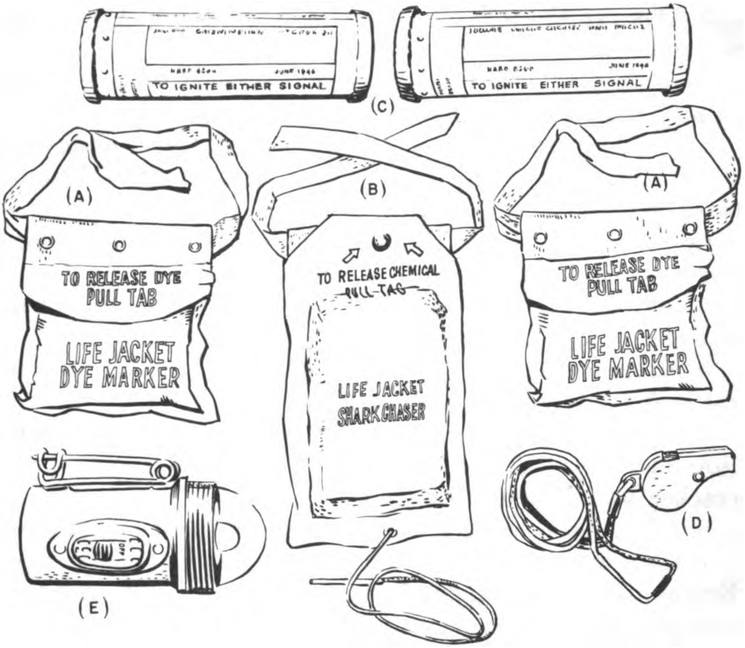

Figure 12–16.—Life vest equipment. (A) Dye marker packets; (B) shark chaser packet; (C) Mk 13 Mod 0 distress signals; (D) whistle; (E) single-cell light.

2. Inflate the vest by mouth to its maximum volume.

3. Adjust the harness adapters to obtain a comfortable snug fit.

4. Remove the vest and deflate by depressing the oval inflator valve. Unscrew the valve lock, and the vest is ready for emergency inflation.

Inspections

PREFLIGHT INSPECTION.—Every wearer must be able to determine the condition of his life vest. The following inspection should be conducted by the individual prior to every flight:

1. Inspect all exposed metal parts for evidence of corrosion. If corrosion exists, report the vest for repair and replace it with one that is satisfactory.

2. Observe the inflator holders and the safety ties which secure the actuating levers in a closed position. These should be tied together with very lightweight threads, applied to aid in preventing accidental discharge.

3. Unscrew the inflator holder caps, one at a time, observing the condition of the CO_2 cylinders. A punctured seal indicates an empty cylinder. Insert the cylinders in the holders—neck-end down. To be actuated, the seal must be in a contacting position with the piercing pins. The holder caps must be screwed down tightly and be fitted with gaskets to prevent leakage.

4. Examine for snags, tears, abrasions, or signs of wear in the vest fabric, seams, and harness.

5. Inventory all emergency equipment, noting their condition and security. Rusty signals should be replaced, and a cracked whistle is of little value.

6. Check harness adjustment to insure against binding.

7. Compartments of the vest must be deflated completely. Entrapped air will expand at higher altitudes, enlarging the vest and causing discomfort under the parachute harness.

PERIODIC INSPECTION.—The following inspections are conducted by Parachute Riggers on all Mk 2 life vests PRIOR TO PLACING THEM IN SERVICE, QUARTERLY ON ALL VESTS IN SERVICE, and SEMIANNUALLY on the representative samples in stores, chosen at random from the shelves:

1. Inspect all fabric and webbing surfaces for chafing or fraying, rejecting badly worn vests.

2. Inspect all exposed metal parts for evidence of corrosion and replace if necessary. Insure that the large wire spring clamp type fasteners are properly secured to the vest lobe, and that a blanket loop (21, fig. 12–14) is incorporated in the waist belt.

3. Inspect security of all equipment tabs, loops, packets, and covers.

4. For the leakage test, EACH of the THREE compartments of the vest are inflated WITH AIR to a pressure of 2 p. s. i., and the vest hung on a rack for 12 hours. After this period, no loss of rigidity is to be permitted without rejection of the vest from service. In conducting this test, each compartment is

tested individually and compensation should be made for changes in temperature. During these tests, the CO_2 inflators are removed and a low-pressure tire valve is installed in each threaded manifold for retaining air in the CO_2 compartments. Figures 12–17 illustrates the steps and equipment necessary for conducting the leakage test.

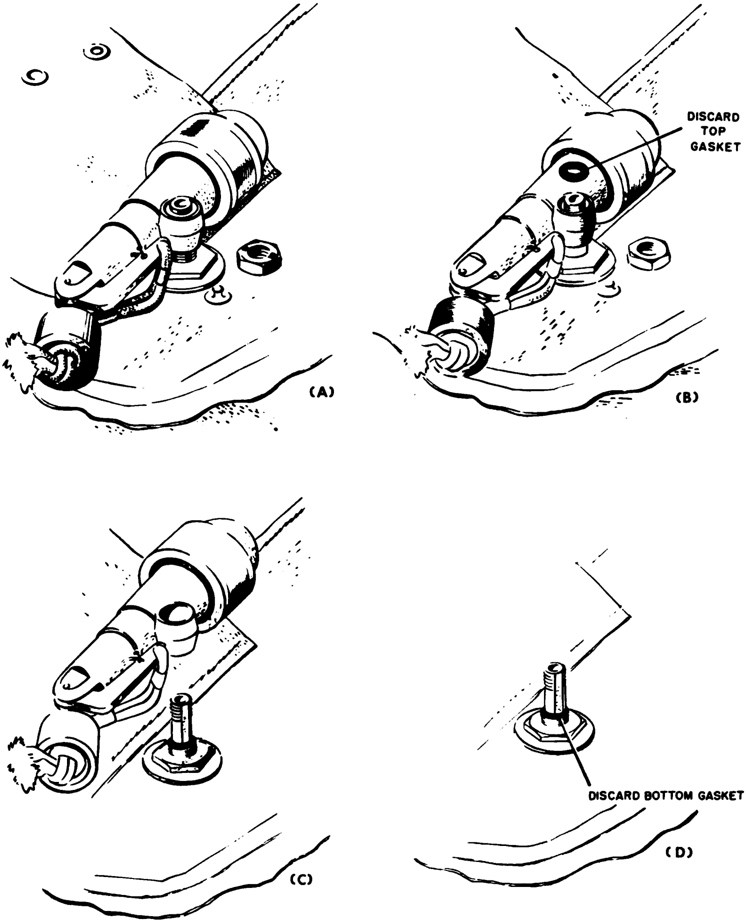

Figure 12–17.—Life vest leakage test. (A) Remove hexagonal cap nut which secures CO_2 inflator to the manifold; (B) remove and discard top gasket; (C) remove CO_2 inflator; (D) remove and discard bottom gasket.

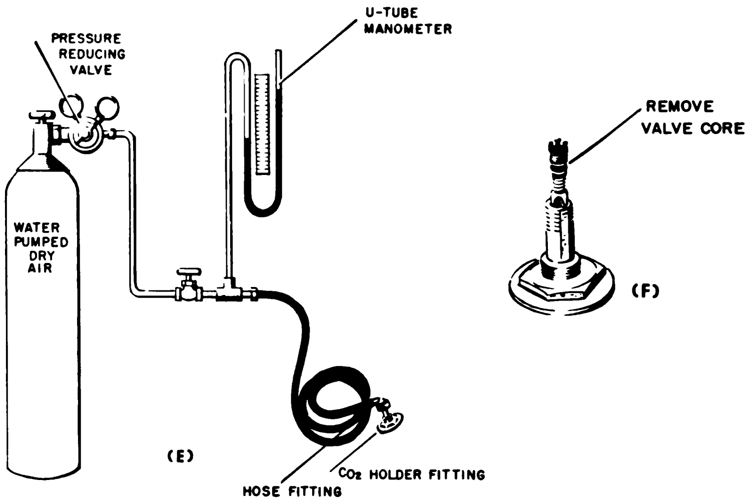

Figure 12–17.—Life vest leakage test—Continued.

(E) install valve core in threaded manifold and inflate CO_2 compartments; and (F) upon completion of the test, remove the valve core.

***Note:* Upon removal of valve core: (1) install new bottom gasket (9/32-inch I. D.); (2) replace CO_2 inflator; (3) install new top gasket (11/32-inch I. D.) and (4) reinstall inflator assembly and secure hexagon cap nut.**

The proper functioning of each vest is determined by discharging a CO_2 cylinder into each of the CO_2 compartments in the normal manner. Both CO_2 compartments must be instantly inflated. Deflation of these compartments is accomplished by removing the holder caps so as to insure an unrestricted passage of gas through the holder assemblies. To expel the entrapped gas completely, press and roll the vest compartments in the direction of the holder assemblies. The oral inflation valve must be held down while working the vest to expel the air from its compartment. Always expel the air from the center compartment of the vest last.

After a vest has passed the inspection and tests successfully, the person responsible must indicate the date and his name in INDELIBLE INK directly on the fabric of the vest. The record form, approximately 5½ inches by 6 inches, is shown in figure 12–18. The most applicable location for

INSPECTION RECORD			
DATE	NAME	DATE	NAME

Figure 12–18.—Life vest inspection record form.

this indelible stamp to be applied is under the collar area where it lies across the back.

Maintenance

PATCHING.—The application of patches to repair holes and tears is accomplished as follows:

1. Cut a scalloped patch of neoprene-coated nylon vest fabric large enough to extend beyond the damage for a margin of 1½ inches. Place the patch in position over the hole and mark around the patch.
2. Clean the marked area and the underside of the patch with aliphatic naphtha (or other suitable safety solvent) and allow it to dry.
3. Apply three coats of cement (conforming to the applicable specification adaptable to neoprene-coated fabrics) to the surface of the damaged area, allowing ample time for each coat to dry.
4. Apply three coats of cement to the inside of the patch, allowing ample time for the first two coats to dry. When

the last coat is tacky, lay the patch over the tear and roll it down, being careful not to trap air between the two cemented surfaces.

SEAMS.—Seams which show signs of opening (loss of adhesion) are repaired in the following manner:

1. Clean the inside of the opened seam with a neoprene cement solvent as recommended by the cement manufacturer.

2. Thin a small quantity of cement by adding an equal amount of toluene or a suitable thinner specified by the manufacturer and mix thoroughly. Apply the thinned cement to the washed area on each of the two sides of the seam covering the entire area as much as possible; allow to dry.

3. Apply three more coats of the thinned cement to each side of the seam and one coat of full strength cement to each side of the seam. Allow sufficient time for each coat to dry.

4. When the last of these coats has become tacky, press the seam together and roll it down firmly, being careful not to trap air between the two cemented surfaces.

5. Next, apply four coats of thinned cement and three coats of full strength cement to the outside of the seam.

6. When the last of these coats has become tacky, fold a piece of tape 1½ inches wide conforming to the specifications over the prepared section of the seam with the cemented faces adjoining. Roll the seam to insure the exclusion of air and to obtain a tight bond between surfaces.

CLEANING.—The vest may be cleaned with mild soap and water only, followed by a thorough rinsing and drying. For removing old cement, grease, paint, or similar stains from surface areas, use aliphatic naphtha or other suitable safety solvent. When using solvents for this purpose, exercise caution not to dissolve too much of the rubber coating. Always use solvents in well-ventilated surroundings.

SURVEY.—Life vests exceeding a five years storage or service life are surveyed and replaced.

STOCK NUMBERS AND DESIGNATIONS.—Throughout this volume and the first, numerous references have been made to material items involving ASO and GSK stock numbers. At present, there is a program initiated to standardize equipment which is common to all branches of the service. In doing this, these items will be assigned new stock numbers in conjunction with the new program. Eventually, all goods used by all services will be indexed and catalogued under this system. Through cross index listings, old stock numbers (those not considered ancient) retain indexing values for many months after discontinuance. The title of the new catalogue to be used by the Navy involving aviation equipment is: *Navy Stock List of the Aviation Supply Office*.

QUIZ

1. The nature and design of flight clothing
    - a. is progressing into a more overall protective stage
    - b. has changed very little during the last 10 years
    - c. is primarily for protection against extremely cold temperature
    - d. has almost reached its ultimate, progressively
2. The antiexposure suit is
    - a. classified as flight clothing
    - b. worn on all overwater flights
    - c. classified as protective clothing
    - d. rapidly becoming obsolete due to the design of modern aircraft
3. Modifications on flight clothing
    - a. may be made at the discretion of the individual pilot
    - b. should never be made without due consideration of all safety factors involved
    - c. must never be made without approval of the commanding officer
    - d. are relatively unimportant
4. The protective helmet was designed primarily
    - a. to keep the head warm
    - b. to be worn by aircrewmen of multiengine aircraft
    - c. to protect the head during a crash
    - d. for use as a mount for the lip microphone and goggles
5. The boom microphone is attached to the protective helmet on the
    - a. front and center of helmet
    - b. right or left side, according to the pilot's preference
    - c. right side
    - d. left side
6. The lightweight summer flying suit
    - a. is sometimes used in lieu of the anti-g suit
    - b. is used more extensively in small single-place aircraft
    - c. should not be used in fighter type aircraft
    - d. should be treated with a fire-retardant compound
7. Flight clothing
    - a. can be found in class 37 of the *Aviation Supply Office Catalog*
    - b. may be found in class 37 and class 83
    - c. is usually found in class 37 of the *GSK Catalog*
    - d. is found in all of the above

8. Damaged articles of flight clothing, such as flight suits, boots, goggles, and gloves,
    a. should always be repaired by the Parachute Rigger
    b. may be disposed of by the squadron Flight Equipment Officer
    c. is usually surveyed by the squadron Material Officer
    d. must be returned to stores before a replacement can be reissued

9. First aid kits are
    a. ordered from supply by the squadron Material Officer for installation in new aircraft
    b. removed from the aircraft upon transfer or release (of the aircraft) from a squadron
    c. regularly inspected by the Medical Department
    d. delivered as an item of equipment with all new aircraft

10. The bladders and tubing of the anti-g suit are
    a. not interconnected
    b. made of rubber coated nylon
    c. made of nylon, impregnated and coated with vinyl resin
    d. natural rubber

11. In order to keep the anti-g suit bladders and tubing from collapsing,
    a. a coiled wire covered with a nylon screen is placed inside them
    b. they are never completely deflated
    c. there is a check valve built in them which will keep them inflated to 0.01 p. s. i. per g at all times
    d. they should be fully inflated every three days

12. Of the two types of anti-g regulating valves currently in use, the
    a. NAF 1233 is automatically actuated after 1.50 g's are attained
    b. JP–9 (NAF 1237) has a high and low setting and is used in reciprocating engine aircraft
    c. valve used in jet type aircraft can be operated manually
    d. JP–9 inflates the suit to 1.25 p. s. i.

13. The anti-g suit is laundered
    a. in a slow, tumbler type washing machine with lukewarm water
    b. by hand, using lukewarm water
    c. by either washer or hand, providing the washer is a slow tumbler type and the water is lukewarm
    d. in cold water and then ironed, being careful not to iron over any of the bladder system

14. Entrapped air inside an antiexposure suit
    a. reduces its efficiency
    b. gives a positive means of buoyancy
    c. increases its efficiency
    d. has no adverse or beneficial effect whatsoever

15. The complete Mk 4 antiexposure suit consists of four major components. They are the outer garment, the insulation liner, the
    a. parka hood, and the boots
    b. gloves, and the g-suit hose covering
    c. boots, and the g-suit hose covering
    d. neck seals, and the wrist seals
16. The cloth of the outer garment of the Mk 4 antiexposure suit is coated with a neoprene base compound. This coating is on
    a. the inside of the suit
    b. both inside and outside
    c. the inside on some sections and the outside on other sections
    d. entirely on the outside
17. Which of the below should NOT be done when putting on the antiexposure suit?
    a. Stretch the neck seal.
    b. Pull on the boots.
    c. Allow the neck seal to bunch up.
    d. All of the above.
18. To obtain a watertight antiexposure suit, the following general rules should be adhered to:
    a. Always join two cemented surfaces while the cement is wet.
    b. Apply three coats of cement to rubber surfaces and two coats to fabric surfaces.
    c. Let each coat of cement dry ten minutes, then apply the next coat.
    d. Apply three coats of cement to fabric surfaces and two coats to rubber surfaces.
19. The formula for fitting the neck seal to the wearer is the circumference of the neck
    a. −2½ inches÷2
    b. −2 inches×2
    c. +2½ inches÷2
    d. +2 inches÷2
20. In cutting the suit leg for attaching the antiexposure boot,
    a. it is better to leave too much slack than not enough
    b. no slack should be left
    c. too much slack will cause damaged seams
    d. it is better to have the leg slightly tight than to have a small amount of excessive slack
21. Quick-donning antiexposure suits
    a. are single piece suits
    b. consist of two major parts
    c. come in two sizes only
    d. entirely covers the wearer with the exception of the head

22. A fully inflated Mk 2 life vest will give a minimum buoyancy of
    a. 20 pounds
    b. 25 pounds
    c. 30 pounds
    d. 10 pounds

23. Which of the following statements is NOT true concerning the Mk 2 life vest?
    a. Two of three compartments cannot be orally inflated.
    b. Its maximum buoyancy can be obtained by inflating the center compartment only.
    c. All three compartments can be inflated by CO_2 gas.
    d. Maximum buoyancy cannot be obtained by carbon dioxide gas only.

24. The survival equipment secured to the life vest includes
    a. a two-cell flashlight
    b. two shark chasers
    c. two distress signals
    d. a mirror

25. Life vests are given periodic inspections, which includes a leakage test
    a. prior to placement in service and quarterly thereafter
    b. every sixty days
    c. every six months
    d. prior to placement in service and every six months thereafter

CHAPTER 13

SAFETY BELTS AND SHOULDER HARNESSES

If an award could be given to an inanimate item of equipment for the most successful record of saving lives, as well as preserving them, the safety harness (belt and shoulder straps) would take it. Actually, no award would be adequate from a repayment standpoint, as this "famous pair" is forever on the job working to keep airmen in their seats. Keeping a pilot in his seat, away from the danger of falling out or bumping against the interior of a cabin, is a full-time problem, and one that has been met with great success. When wearing a safety harness, pilots can survive any crash where the cockpit or cabin remains reasonably intact. Many surface type craft have adopted its use either in part (belt only) or in its entirety.

What the harness team must offer can be condensed into one statement: The lap belt and shoulder harness combination must be strong enough to hold a man in his seat under all reasonable stress conditions as experienced in high-speed flight, arrested landings, barrier, or nose-over crashes. It must be so designed that it can be released quickly. What the tensile strength requirements are, how the harness and belt are mounted, and how they are released will be discussed in detail under the respective types.

PILOT'S LAP BELT AND SHOULDER HARNESS

Pilots' safety belts can be furnished as complete assemblies, consisting of lap and shoulder straps, or as individual components as listed in class 37, *ASO Catalog*. (See fig. 13–1.)

LAP BELT SPECIFICATIONS.—Figure 13–2 illustrates the belt's dimensions, its stitching pattern, how it is put together, its parts, and other significant physical characteristics.

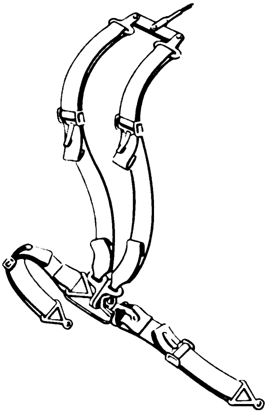

Figure 13-1.—Pilot's safety belt and shoulder harness.

The lap belt is designed to take an ULTIMATE LOAD OF 9,000 POUNDS without failure in the webbing, fittings, or stitched joints; however, a deformation under this maximum load does not constitute a rejection of the manufactured lot. Also, during manufacture, belts are submitted to 6,000-POUND PROOF TESTS. After this test, no excessive deformation of the parts or stitching is permitted in the assembly. The latch must work freely when the load is released. The ultimate load and proof load requirements applied to a lap

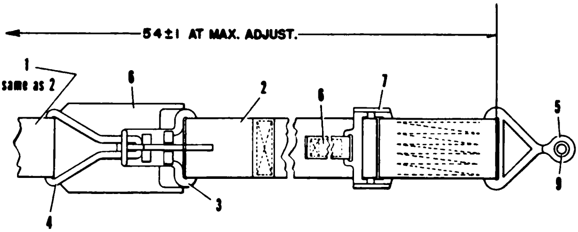

Figure 13-2.—Lap type safety belt.

1. Right side of belt (3-inch nylon webbing).
2. Left side of belt (3-inch nylon webbing).
3. Latch assembly.
4. Link.
5. Loop.
6. Washers, rivets, and leather protector.
7. Adjuster.
8. Pull tab.
9. Bushing.

belt immediately after its manufacture (at the plant) should not be confused with the periodic service tests given this equipment in the field. Field test loads do not even approach the tensile strength capacity of the assembled belt. All major stitching is done with 5-cord nylon thread, size E being used in the less important tensile strength areas.

Shoulder harness specifications.—Figure 13–3 illustrates the shoulder harness' dimensions, its stitching pattern, how it is put together, its parts, and other significant physical characteristics. The Y and V types are shown in figure 13–4. Where the lap belt remains fairly standard in its attachment to the pilot's seat, the shoulder harness must quite often be modified to fit its anchored location. This subject will be discussed under installation.

The anchor plate of the Y type is adjustable, making it possible to lengthen or shorten the harness. During the manufacture and before acceptance, shoulder straps are subjected to a 3,500-pound tension load. A reasonable deformation of the parts is permissible. A proof load of

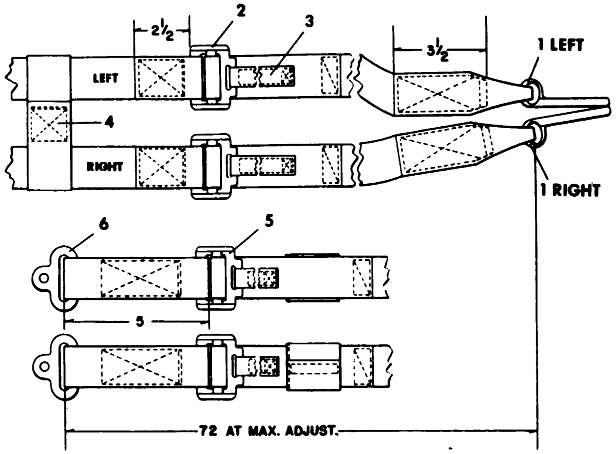

Figure 13–3.—Shoulder harness with *separating* keeper (resembles an H).

1. **Link (left and right).**
2. **Adjuster.**
3. **Pull tab.**
4. **Keeper.**
5. **Adjuster.**
6. **Plate attachment.**

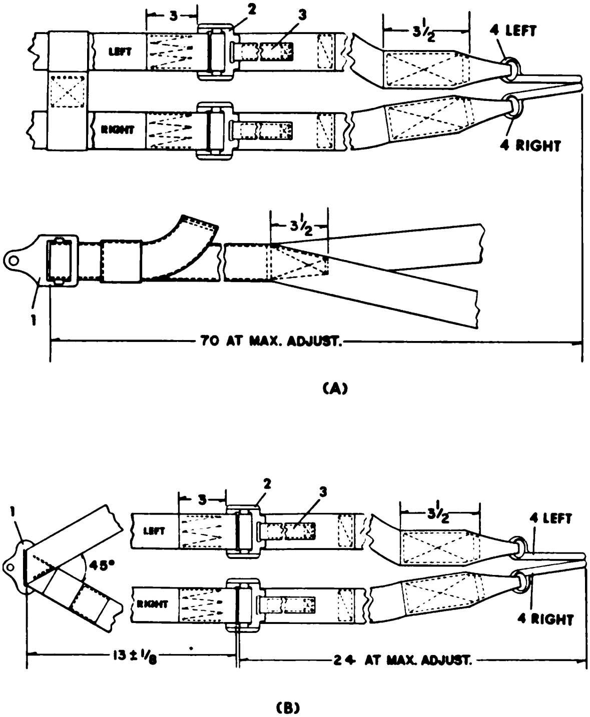

Figure 13–4.—Pilot's shoulder harness. (A) Y type; (B) V Type.

1. Attaching plate.
2. Adjuster.
3. Tab.
4. Links, left and right.

3,000 pounds, and the straps shall not have slipped appreciably through the adjustment loops. No noticeable deformation of any kind is permitted in this test. The proof test, then, establishes the highest tensile strength load a shoulder harness will withstand and still operate perfectly afterwards. The ultimate test is designed to stop at a tensile strength value just short of complete destruction. With reasonable care and by applying preventive measures, the shoulder harness will give long and honored service, easily passing its field test loads. The latest straps are made of DACRON, another new "miracle fiber," similar to nylon.

Work is progressing on an automatic type safety belt and shoulder harness, used in conjunction with the ejection seat, which is operated by a cartridge. Its operating principle is simple: During ejection of the seat, a delayed timing action is actuated. In turn, this sets off a cartridge fastened to the seat's structure; piston-action in the cartridge cylinder finally pulls the cable or lanyard which is secured to a link holding the safety belt and shoulder harness to the wearer. If the automatic release fails, the belt and straps can be released manually in the normal way. This automatic feature is designed to eliminate the dangerous practice, brought on by excitement, of releasing the safety harness before ejection from the aircraft. When a man knows he will be released from his seat automatically after he is in the air, he is not likely to make the mistake of releasing himself manually ahead of time. Most everything is being designed to keep pace with ever-increasing speed.

OTHER SAFETY BELTS

Crewman's safety belt.—The crewman's safety belt is designed to permit a reasonable amount of movement of the wearer in performing his duties while securely holding him in the aircraft. An aerial cameraman would use one of these when shooting oblique assignments out of open hatches. The tail strap which is adjustable (22 inches to 65 inches, approximately) can be anchored to any strong

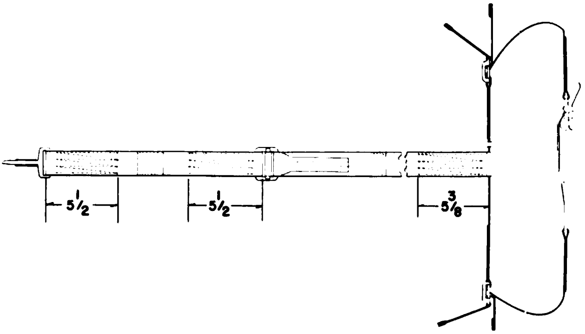

Figure 13–5.—Crewman's safety belt.

part of the aircraft's structure which is adaptable to its hook. (See fig. 13–5.) Normally the smaller amount of tail strap payed out, the less will be the danger of being whipped about when the airplane is maneuvered violently.

As the crewman makes the attachment, he should anchor to a strong structural member making certain that the attachment will not mar or damage equipment.

GUNNER'S BELT.—The gunner's belt side straps permit more movement than the pilot's type (which is designed primarily to hold him solidly in his seat). The length of the gunner's belt side straps is adjustable, thereby permitting the wearer security in standing as well as in sitting. (See fig. 13–6.)

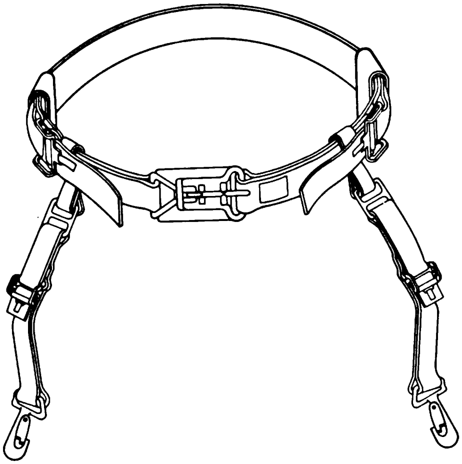

Figure 13–6.—Gunner's safety belt.

PASSENGER BELT.—The passenger belt, familiar to those who have used the commercial airlines, does not share a wide use in naval aviation. The belt is applied to the troop or passenger seats in utility type aircraft. It also has the quick release feature, so important to the design of the belts used in combat aircraft. The buckle can be released by one hand. The webbing is narrower than the pilot's type. Do not be misled by this fact as it is able

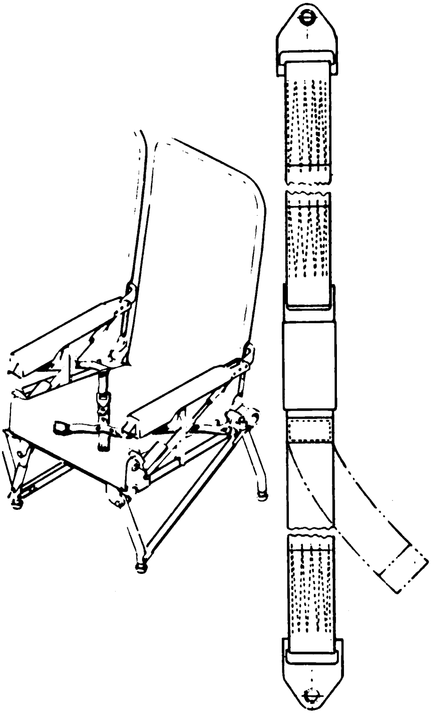

Figure 13-7.—Passenger type safety belt.

to withstand an ultimate load (during manufacture) of 5,000 pounds. All major stitching is accomplished with 3-cord nylon thread. Figure 13-7 illustrates the belt and its application.

SAFETY HARNESS AND INERTIA REEL

The safety harness and inertia reel system consists of the pilot's shoulder harness (sometimes referred to as the safety harness), the inertia reel, the harness control handle, and connecting cables. The harness control handle is usually mounted on the left-hand side of the pilot's seat. The inertia reel control cable is generally attached to the harness control handle and connects to the inertia reel on the fuselage fuel cell compartment cover just aft of the pilot's seat. (See fig. 13–8.) There are numerous other places that the inertia reel may be located. For specific information about a particular airplane, consult the pertinent *Handbook of Maintenance Instructions*. The safety harness cable leads forward from the inertia reel, and attaches to the safety harness fittings. The ends of the two harness straps are stitched to buckle fittings which latch to the belt buckle and are held in place when the lap belt is buckled. When

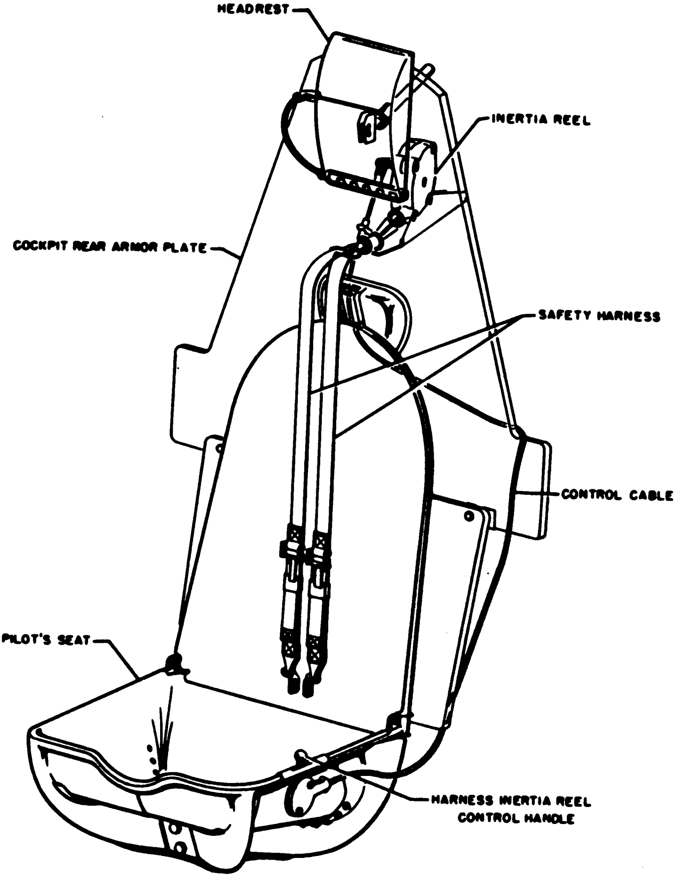

Figure 13–8.—Inertia reel and safety harness.

the harness control handle is in the locked or forward position, the safety harness cable will not extend. When the harness control handle is in the unlocked or rear position, the safety harness cable will extend and retract easily. The inertia reel consists of an inertia reel case which houses a spring-loaded drum on which is wound the harness cable. If the airplane decelerates with a force of 2.5 g's or more, the inertia reel automatically locks. When the tension is released, the harness cable retracts.

Testing and Troubleshooting

1. Move the harness handle back and forth. The handle should stay securely locked or unlocked when in position; and the inertia reel should lock and unlock easily.
2. With the harness control handle in the locked position, the safety harness cable should not extend.
3. With the harness control handle in the unlocked position, extend and retract the safety harness cable several times. Operation should be smooth.
4. Place the harness control handle in the unlocked position. Then, holding the safety harness cable partly extended, move the harness control handle to the locked position. The safety harness cable should not extend further, but should retract freely.
5. Place the harness control handle in the unlocked position. Then, while extending the safety harness cable, strike

Table 13-1.—Safety harness and inertia reel troubleshooting

Trouble or symptom	Probable cause	Correction
Control handle fails to lock or unlock inertia reel.	Kinks or obstructions in control cable.	Remove kinks or obstructions.
	Defective control assembly.	Replace control assembly.
	Defective inertia reel.	Replace inertia reel.
Harness cable fails to operate properly.	Harness cable obstructed or kinked.	Remove obstruction or kinks.
	Defective inertia reel.	Replace inertia reel.

the front of the inertia reel sharply with the hand to simulate g-pressure. The inertia reel should lock, but the safety harness cable should retract when tension is released.

If the inertia reel is defective, replace it. Do not attempt to repair the reel.

Displace the rubber support which protects the swaged cable end and inspect the cable for fraying at the swaged end. If the cable is frayed, replace the inertia reel cable.

Installations

The anchoring points of safety harnesses quite naturally vary with different type airplanes, and when we consider the pilot's seat, copilot's, navigator's, flight engineer's, and others in larger aircraft, we can visualize the installation problems. Specific information can be found in the aircraft's manuals. Regardless of the occupant of a particular station, there are a few simple principles that can be applied to the installation of all safety harnesses. Some texts refer to the entire arrangement (safety belt and the shoulder harness) as being the safety harness while others only mean the shoulder harness. Whenever following installation directions be certain you know the part being referenced. Since the belt and shoulder straps have been designed to withstand a terrific amount of stress (more than human endurance), it is only reasonable to match the anchoring points with the tensile strength of the entire safety harness. This is done by the manufacturer, BUT THE SECURITY OF THE ANCHORING DEVICES CAN BE LOST BY A POOR INSTALLATION.

The general installation rules are as follows:

1. Where applicable, use only steel bolts and nuts.
2. Use only stop nuts, or the castellated type, which require a cotter pin through the bolt and castellations of the nut to prevent loosening.
3. Apply nuts, especially the type requiring a cotter pin, in such a way that they will not catch on the parachute or clothing.
4. Whenever possible, belts and harnesses must be installed without interruptions in their "fair lead" (a course of running or standing line, webbing, or cable that avoids all chafing).

Certain designs make this impossible, and when such is the case, make certain the webbings being carried in a new direction are placed over the top of a strong structural member, whether it be on the seat or some other part. The structural member, acting as a guide, must be smooth.

5. The installation must not interfere with other equipment and the escape procedures outlined for a specific aircraft. In no way must the path of an ejection seat be obstructed.

6. To establish the correct relationship, left sides of belts and shoulder harnesses are installed on the left side of the seat as viewed from its rear. Not all seats face forward in an aircraft.

7. All belts must be installed in such a way that they can be released with the right hand. Excess webbing lengths can be cut from belts and straps providing everyone (all sizes) can be served adequately by the assembly. Whenever the ends of the webbing are shortened, they must be properly folded or doubled and then sewed with the proper size cord as specified by the manufacturer of the equipment.

8. Prevent the danger of loose webbing ends being dragged free from their adapters! Do not permit short loose-end conditions following a long-reaching adjustment. In some cases, it may be advisable to make a tacking in a webbing assembly to prevent this dangerous slippage. In doing it, strike a universal or midway position of the shoulder adapters in relation to the collarbone area of short and tall pilots. The shoulder adapters of the shoulder harness should be adjusted in such a way that they fit just below a man's collarbone and not over it. Over the collarbone, they can cause bruising and are therefore uncomfortable.

9. The hardware used in the assemblies must be so designed to prevent chafing the webbing. Any filing of rough edges must be accompanied by a plating process to prevent rust.

Figures 13–9 and 13–10 illustrate two typical examples of a complete safety harness installation in an attack type aircraft. Notice the location of the inertia reel controls in figure 13–10.

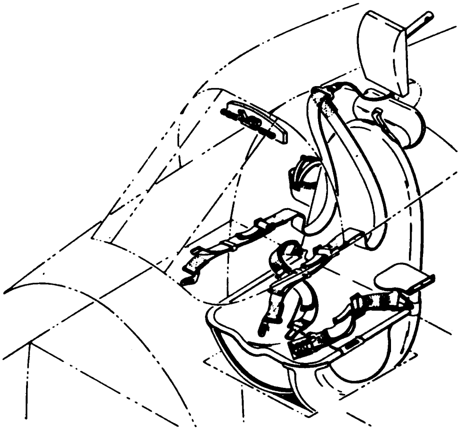

Figure 13–9.—A pilot's safety belt and shoulder harness installation.

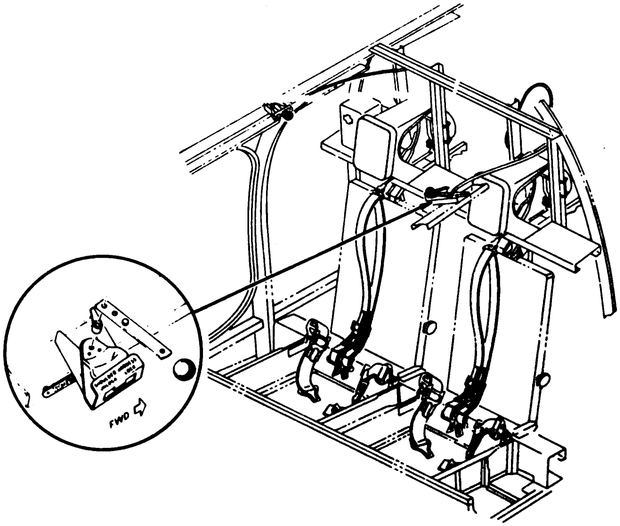

Figure 13–10.—Crewman's safety belt and shoulder harness installation.

Service Inspections and Tests

PRIOR TO EACH FLIGHT.—Safety belts and shoulder harnesses are inspected for obvious signs of wear or deterioration of the metal parts and for wear or fraying of the webbing. Release buckles, snaphooks, and other operating parts must be checked for proper functioning.

AFTER EVERY 60 HOURS OF FLIGHT.—Belts and shoulder harnesses are inspected for corrosion, cracks in metal parts, wear or other signs of deterioration, rotting, cutting or fraying of webbing, and for proper functioning of the simple releasing mechanisms. Any part of the aircraft's structure securing and coming in contact with the shoulder harnesses and belts must be given a thorough inspection for jagged or rough edges which could cause damage to the equipment. Loose rivets in the anchoring points and other early signs of weakening must be discovered.

EVERY 6 MONTHS.—Remove belts and straps from aircraft, inspect bolts and inside of fittings for initial signs of breakdown, and test equipment for tensile strength.

The in-service tensile strength tests follow:

1. Pilot's lap type belt—2,750 pounds.
2. Shoulder harness (H and Y types)—2,250 pounds tested as a unit.
   For the H type—1,125 pounds to each strap.
   For the V type, 2,000 pounds, tested as a unit.
3. Waist band of gunner's belt—2,000 pounds.
4. Side straps of gunner's belt—1,100 pounds.
5. Troop and transport passenger belts—1,250 pounds.

After application of the specified loads, there can be no signs of weakening or failure in the metal parts, webbing, or stitching. There shall be no perceptible slippage of the webbing through the adjustment loops, and the lap belt release must work freely. The quick release buckle of the lap belt shall be operable under a pull of not over 45 POUNDS ON THE LATCH WHILE THE BELT IS SUBJECTED TO A STATIC LOAD OF 400 POUNDS.

Testing Machine

Any one of several methods may be used for applying the prescribed proof load to the belts and straps; for example, mechanical tension testers, tripod lifts, dead-weight loading, and others. There is no limit to the manner in which the test loads can be applied; accuracy of the actual load is the important thing.

A testing jig is made from salvaged material shown in figure 13–11. Its capacity is approximately 5,000 p. s. i., a necessary reserve in power. The device can be mounted horizontally or vertically depending on the dictates of the physical plant. The movable head and the stationary head should be mounted far enough apart so that all lengths of belts and harnesses together with their necessary mounting clamps or adapters can be accommodated. In many cases, these have to be manufactured locally. Any Parachute Rigger can design the special jig necessary to do the job. For example, the part used in the aircraft to hold the mounting plate of a shoulder harness can be rigged to a testing jig and be used for the same purpose during test.

The device shown in figure 13–11 is adequate. Its construction details need not be followed closely. As a precaution, a wire cage must be constructed and placed over the area that lies between the two attachment heads. Then the operator will be guarded against the possibilities of

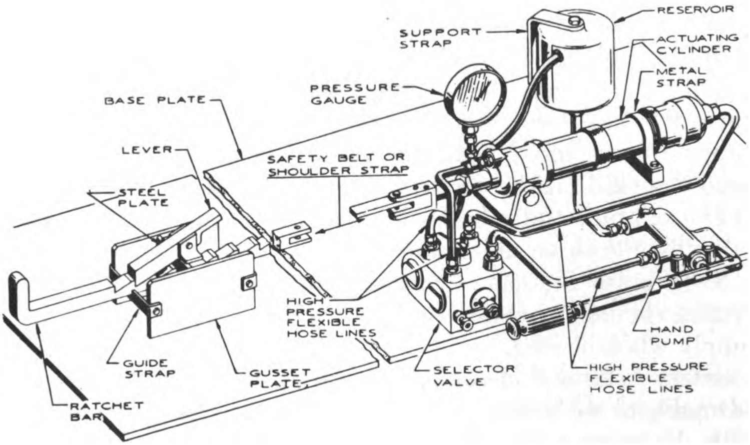

Figure 13–11.—Safety belt and shoulder harness testing jig.

sudden breakage and the accompanying whipping action that takes place.

CALIBRATION.—After construction of a testing device it will be necessary to recalibrate the pressure gage from p. s. i. to pounds. This will insure an easily read value in relation to the specified tension load. Calibration can be done by any of the methods suggested below. The load in pounds (50-pound increments) can be marked directly on the gage dial, or a chart may be prepared to indicate the equivalent load in pounds for the corresponding p. s. i. graduations.

1. DEADLOAD. Secure the actuating cylinder in an upright position with the piston rod downward. Record the pressure (p. s. i.) required to lift deadloads of known weights.

2. SPRING. Place a large capacity spring scale of known accuracy between the two jaws of the test device and apply pressure. Record the loads in pounds shown on the scale versus the pressure in p. s. i. indicated by the gage.

3. DYNAMOMETER. Place a loop or Chatillon dynamometer of approximately 5,000 pounds capacity between the two jaws of the testing device and apply pressure. Record the load in pounds against the p. s. i. indicated by the gage.

OPERATION.—The device requires only one man to operate it. Secure one end of the belt or shoulder strap to the ratchet rod and the other end to the piston rod. The length of the adjustable ratchet and the piston rod will afford sufficient clearance for testing belts of various lengths. Turn the selector valve handle to the loading position. Apply the required load by operating the hand pump. Read the load on the calibrated gage. Hold for 30 seconds to one minute, and release the load by turning the selector valve handle to an unloading position.

Recalibrate the gage every six months; breakages in the system should be repaired as they occur. Replenish the oil supply when needed.

Safety belts and shoulder harnesses found to be damaged or unable to withstand the strains of testing shall be replaced with the latest equipment.

TESTING JIG.—Figure 13–12 illustrates the application of

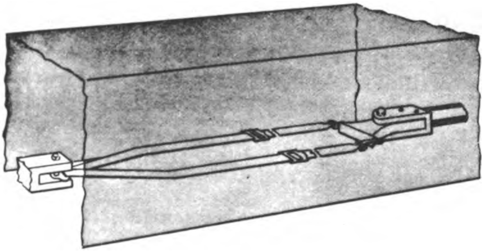

Figure 13–12.—Application of jig to shoulder harness.

a testing jig. The jig is adaptable to Y and V type shoulder harnesses, also the H type. The anchoring adapter shown in figure 13–12 is not made in accordance with a specified drawing. However, the important thing to consider is its adaptability to the type belt or strap arrangement being tested. As long as an anchoring adapter does not produce any twists or undue strain on the article under test, it may be considered adequate.

RESCUE SLING

The Parachute Rigger is responsible for the repair and maintenance of all aviation survival equipment and for many things remotely connected. A helicopter survivor's rescue sling is one of these items, since it is constructed of fabrics, webbings, and tapes similar to the kinds used in parachutes.

The survivor's sling is intended to be worn by persons who are to be hoisted to safety in sea-air or land-air rescue operations. The sling is terminated by two V-rings which are attached to the hook at the end of the rescue cable. The survivor's sling can be worn in a number of ways. One method is to pass the head and shoulders through the loop formed by the sling and allow the padded portion to rest across the back and under the armpits.

A crewman's sling is worn by personnel who are lowered to assist in rescue operations. It is worn by looping the sling under the armpits with the padded portion of the sling across the wearer's back. The sling hardware is forward of the wearer when the sling is properly donned.

A cable grip, by virtue of its design, permits the crewman to attach himself at any point along the cable as it is payed out from the winch.

QUIZ

1. On the lap type safety belt the latch assembly
    a. is always on the left
    b. is always on the right
    c. is on the left in some cases and the right in others
    d. may be on either side
2. Which of the below is a part of the lap type safety belt?
    a. Loop
    b. Adjuster
    c. Bushing
    d. Adapter
3. The part of the lap type belt that the latch hooks in is known as the
    a. loop
    b. link
    c. V-ring
    d. bushing
4. During periodic field tests lap type safety belts are
    a. tested to within a few hundred pounds of their ultimate load
    b. tested to within 3,000 pounds of their ultimate load
    c. not tested at a tensile strength approaching their ultimate load
    d. tested to their approximate ultimate load
5. All major stitching on lap type belts is done with
    a. 6-cord nylon thread
    b. 5-cord nylon thread
    c. 5-cord nylon and size E nylon
    d. either 5-cord nylon or 6-cord nylon
6. The shoulder harness is secured to the lap belt by
    a. inserting the lap belt link through the shoulder harness links
    b. inserting the lap belt link through the shoulder harness links and securing the latch
    c. hooking the latch of lap belt in left link of the shoulder harness
    d. hooking the latch of lap belt in both links of the shoulder harness

7. The Y type shoulder harness
    a. incorporates a keeper strap as part of the complete assembly
    b. has 2 anchor plates
    c. is used in patrol type aircraft only
    d. is adjustable at the anchor plate
8. The latest shoulder straps are made of
    a. dacron
    b. nylon
    c. a combination of dacron and nylon
    d. orlon
9. The automatic type safety belt is primarily for use
    a. in conjunction with the ejection seat
    b. in experimental type aircraft
    c. with jet trainer aircraft
    d. in all aircraft with speeds in excess of 450 m. p. h.
10. The automatic belt was designed primarily to help eliminate the possibility of
    a. becoming entangled in the safety belt and harness
    b. an injured pilot not being able to release himself.
    c. not being able to release the safety belt because of a faulty link or latch assembly
    d. releasing the safety harness before ejection from the aircraft
11. An aerial cameraman shooting oblique assignments out of open hatches would use a
    a. V-type safety harness
    b. gunner's belt
    c. passenger type safety belt
    d. crewman's safety belt
12. When using the gunner's belt,
    a. it completely encircles the wearer's body
    b. it holds the wearer firmly in his seat
    c. the latch is on the opposite side from which it would be on a lap belt
    d. the wearer CANNOT be in a standing position
13. The tail strap of the crewman's safety belt
    a. should be anchored at the "tail strap anchor point"
    b. may be anchored at any strong, structural part of the aircraft which is adaptable to its hook
    c. must be anchored at, or near, the wearer's seat
    d. is NOT anchored on any of the above places
14. The passenger belt differs from the pilot's lap belt in that it
    a. takes both hands to release it
    b. is installed opposite from the way the lap belt is installed
    c. does have the quick release feature
    d. is NOT used in military aircraft

15. The safety harness inertia reel system consists of the
    a. pilot's shoulder harness, inertia reel, harness control handle, and the seat adjustment handle
    b. seat adjustment handle, harness control handle, and inertia reel
    c. pilot's shoulder harness, inertia reel, harness control handle, and connecting cables
    d. safety harness, harness control handle, inertia reel, and lap belt
16. When the harness control handle of the inertia reel system is in the locked position, the safety harness cable will
    a. extend only a few inches
    b. NOT extend
    c. neither extend nor retract
    d. retract and extend only 3 inches
17. If the aircraft decelerates with a force of 2.5 g's or more, the inertia reel
    a. remains static
    b. will not operate
    c. automatically unlocks
    d. automatically locks
18. With the harness control handle in the unlocked position the inertia reel cable should
    a. extend and retract freely
    b. extend freely but retract slowly with a clicking noise
    c. retract freely but extend slowly with a clicking noise
    d. extend and retract slowly
19. If an inertia reel is found to be defective, it should be
    a. repaired by removing the top cover and replacing the cable in its track
    b. replaced
    c. repaired, if possible, otherwise replaced
    d. left alone if the trouble is not very serious
20. The best procedure to follow to assure that belts and harnesses are properly installed is
    a. ask the pilot or plane captain if they are in the right place
    b. check the *Handbook of Maintenance Instructions* of the aircraft concerned
    c. personally inspect the plane
    d. check the safety harness or belt blueprints
21. The only type, or types, of nuts permissible for use in installing safety belts are
    a. castellated nuts used in conjunction with a cotter pin
    b. stop nuts or castellated nuts which require a cotter pin
    c. plain nuts with lockwashers
    d. any of the above, if they are installed securely

22. Excess webbing lengths on belts and harnesses
    a. should be folded and tacked to keep out of the way
    b. should never be cut off
    c. must always be removed
    d. may be cut off providing the belts and harnesses are left long enough to serve persons of all sizes

23. The shoulder adapters of the shoulder harness should be adjusted to
    a. fit just below the wearer's collarbone
    b. eliminate danger of it breaking during a crash
    c. fit six inches above the collarbone
    d. fit over the collarbone

24. If a rough edge is filed from a piece of harness hardware, it
    a. must be painted with zinc chromate
    b. may be left as is if frequently inspected for rust
    c. must be given a plating process
    d. may be given any of the above remedies

25. Which of the below is NOT an inspection period for safety harnesses?
    a. After every 30 hours of flight
    b. Prior to each flight
    c. After every 60 hours of flight
    d. Every 6 months

26. Safety harnesses are removed from the aircraft and given a tensile strength test
    a. quarterly
    b. every 6 months
    c. after every 120 hours of flight
    d. after every 240 hours of flight

27. The pilot's lap type belt is tested to
    a. 2,250 pounds
    b. 2,700 pounds
    c. 2,750 pounds
    d. 2,350 pounds

28. Troop and passenger belts are tested to
    a. 1,100 pounds
    b. 2,000 pounds
    c. 1,250 pounds
    d. 1,125 pounds

29. The quick release buckle of the lap belt, while subjected to a static load of 400 pounds, should open under a pull of
    a. 40 pounds
    b. not over 40 pounds
    c. not less than 35 pounds
    d. not more than 45 pounds

30. Belts should be tested by
    a. dead weights only
    b. mechanical tension testers only
    c. mechanical testers on dead weights only
    d. any one of several methods so long as the load is accurate

31. The purpose of the wire cage on the tension tester is
    a. to keep from losing any parts in case the belt breaks
    b. for protection of the testing machine
    c. to protect the operator
    d. for stowage of spare parts for the testing machine

32. The gage on a mechanical tension tester should be recalibrated
    a. at least every six months
    b. only when it is discovered to be incorrect
    c. once each year
    d. quarterly

33. Safety belts and harnesses that will not withstand the prescribed tests
    a. should be repaired and retested
    b. shall be replaced with the latest equipment
    c. may be either repaired or replaced according to the circumstances
    d. may be repaired and used on older, slower type aircraft

34. The survivor's helicopter rescue sling was designed to be worn by a
    a. person who is to be hoisted to safety from the sea
    b. person who is to be hoisted to safety from the ground
    c. survivor, to hold him securely in a helicopter after he has been rescued
    d. person who is to be rescued from either the ground or sea

35. A crewman's sling is worn by
    a. personnel who are lowered to assist in rescue operations
    b. all helicopter crewmen
    c. an injured crewman, to hold him secure in the aircraft
    d. a helicopter crewman who is required to move around inside the helicopter to properly perform his duties

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

OXYGEN PHYSIOLOGY AND PRINCIPLES OF AN OXYGEN SYSTEM

1. b.
2. b.
3. a.
4. a.
5. a.
6. a.
7. b.
8. d.
9. c.
10. c.
11. a.
12. b.
13. a.
14. a.
15. d.
16. b.
17. a.
18. c.
19. b.
20. b.
21. d.
22. a.
23. b.
24. d.
25. c.

CHAPTER 2

OXYGEN BREATHING REGULATORS

1. b.
2. a.
3. c.
4. a.
5. c.
6. c.
7. c.
8. a.
9. b.
10. c.
11. a.
12. a.
13. b.
14. a.
15. d.
16. a.
17. d.
18. b.
19. c.
20. b.

CHAPTER 3

INSTRUMENTS AND OXYGEN CYLINDERS

1. c.
2. a.
3. b.
4. d.
5. b.
6. a.
7. a.
8. b.
9. b.
10. a.
11. c.
12. d.
13. c.
14. c.
15. d.
16. b.

CHAPTER 4

TUBING AND FITTINGS

1. b.
2. c.
3. b.
4. c.
5. a.
6. c.
7. b.
8. b.
9. d.
10. a.
11. a.
12. c.
13. d.
14. b.
15. d.
16. b.
17. b.
18. c.
19. c.
20. d.
21. b.
22. c.
23. a.
24. b.
25. b.

CHAPTER 5

AIRCRAFT OXYGEN SYSTEMS

1. d.
2. a.
3. c.
4. a.
5. c.
6. c.
7. a.
8. b.
9. c.
10. b.
11. a.
12. b.
13. a.
14. c.
15. d.
16. b.

CHAPTER 6

OXYGEN MASKS

1. d.
2. c.
3. a.
4. d.
5. a.
6. b.
7. d.
8. a.
9. d.
10. c.
11. d.
12. c.
13. b.
14. b.
15. b.
16. c.
17. a.
18. a.
19. b.
20. b.
21. d.
22. b.

CHAPTER 7

OXYGEN TRANSFER EQUIPMENT

1. c.
2. a.
3. d.
4. b.
5. d.
6. a.
7. c.
8. a.
9. d.
10. b.
11. d.
12. a.
13. b.
14. b.
15. d.

CHAPTER 8

CYLINDERS AND VALVES

1. c.
2. d.
3. a.
4. d.
5. b.
6. c.
7. b.
8. c.
9. c.
10. a.
11. a.
12. c.
13. b.

CHAPTER 9

CO$_2$ SYSTEMS AND RECHARGING

1. c.
2. b.
3. d.
4. c.
5. c.
6. d.
7. d.
8. c.
9. a.

CHAPTER 10

STANDARD LIFE RAFTS AND EQUIPMENT

1. c.
2. d.
3. a.
4. d.
5. a.
6. b.
7. a.
8. d.
9. d.
10. c.
11. b.
12. b.
13. d.
14. d.
15. a.
16. c.
17. a.
18. d.
19. b.
20. d.
21. b.
22. a.
23. c.
24. d.

CHAPTER 11

AIR-SEA RESCUE EQUIPMENT

1. b.
2. c.
3. a.
4. d.
5. a.
6. b.
7. d.
8. d.
9. c.
10. d.
11. d.
12. b.
13. b.
14. a.
15. c.
16. d.
17. b.
18. c.
19. b.
20. c.

CHAPTER 12

PILOT'S PERSONAL AND RELATED EQUIPMENT

1. a.
2. c.
3. b.
4. c.
5. c.
6. d.
7. a.
8. d.
9. d.
10. c.
11. a.
12. c.
13. b.
14. b.
15. b.
16. a.
17. c.
18. d.
19. a.
20. a.
21. a.
22. c.
23. c.
24. c.
25. a.

CHAPTER 13

SAFETY BELTS AND SHOULDER HARNESSES

1. a.
2. d.
3. b.
4. c.
5. b.
6. b.
7. d.
8. a.
9. a.
10. d.
11. d.
12. a.
13. b.
14. c.
15. c.
16. b.
17. d.
18. a.
19. b.
20. b.
21. b.
22. d.
23. a.
24. c.
25. a.
26. b.
27. c.
28. c.
29. d.
30. d.
31. c.
32. a.
33. b.
34. d.
35. a.

APPENDIX II

QUALIFICATIONS FOR ADVANCEMENT IN RATING

PARACHUTE RIGGERS (PR)

RATING CODE NO. 7000

General Service Rating

Scope

Parachute riggers service, maintain, and repair aviation survival equipment, including full-pressure suits: Service and maintain aviation oxygen breathing systems and oxygen test equipment, including liquid oxygen and its conversion and transfer equipment; service and instruct in the use and maintenance of parachutes and other survival equipment, protective clothing, special equipment packets, including air-sea rescue equipment carried by aircraft, oxygen breathing and carbon dioxide equipment, and survival kits; service, maintain, and repair personnel and cargo restraint assemblies.

Emergency Service Ratings

PARACHUTE RIGGERS S (Survival), Rating Code No. 7001----- **PRS**
Maintain, service, repair, and instruct in use and maintenance of parachutes, carbon dioxide equipment for life rafts, safety belts and shoulder harnesses, cargo assemblies, air-sea rescue equipment, protective clothing, and survival kits.

PARACHUTE RIGGERS M (Maintenance), Rating Code No. 7002- **PRM**
Maintain, service, repair, calibrate, and instruct in the operation, use, and care of aviators' breathing oxygen systems, liquid oxygen systems, storage and transfer equipment, servicing equipment, full pressure suits, pressure suit pressure/ventilation controls, composite disconnects, and associated equipment.

Navy Enlisted Classification Codes

For specific Navy enlisted classification codes included within this rating, see Manual of Navy Enlisted Classifications, NavPers 15105 (Revised), codes PR-7300 through PR-7399.

NOTE.—In order to qualify for advancement to PR3 and PRS3, personnel must have met physical requirements as prescribed in the Manual of the Medical Department for student parachute jumpers and have made at least one premeditated free-fall jump under prescribed conditions with a parachute personally packed under the supervision of a qualified parachute rigger.

Qualifications for Advancement in Rating

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
100 PRACTICAL FACTORS			
101 OPERATIONAL			
1. Observe ground safety and handling precautions while working in and around aircraft	3	3	3
2. Use drawings, patterns, and templates in making commonly used assemblies	3	3	3
3. Inspect, rig, pack, handle, stow, and issue all types of personnel parachutes. Be willing to test, by actual jump, under prescribed conditions, any personally packed parachute when challenged by proper authority	3	3	----
4. Inspect, fit, pack, and stow all types of standard aviation protective clothing and survival equipment	3	3	----
5. Operate oxygen regulator test stands	3	----	3
6. Inspect and service all oxygen breathing equipment installed in aircraft and make preflight check in accordance with current instructions	3	----	3
7. Demonstrate knowledge of dry locker procedures	3	3	----
8. Test standard aviation protective clothing and survival equipment	3	3	----
9. Inspect, rig, pack, stow, and issue all types of air survival kits including arctic and tropic	3	3	----
10. Use standard type sewing machines	3	3	----
11. Test CO_2 cylinders for proper charge. Operate CO_2 transfer equipment	3	3	----
12. Operate and maintain high pressure gaseous oxygen transfer equipment	2	----	2

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
101 OPERATIONAL—Continued			
13. Operate liquid oxygen transfer equipment from storage tanks to transfer trailers and from trailers to aircraft converter systems	**2**	----	2
14. Construct a lift web and sling assembly for use on cargo to be dropped with aerial delivery parachutes	**2**	2	----
15. Demonstrate emergency parachute jumps and use survival equipment under simulated conditions	**2**	2	----
16. Operate vacuum pumps and associated equipment for evacuating liquid oxygen storage tanks and transfer trailer tanks	**2**	----	2
17. Control dry locker temperature and relative humidity	**2**	2	----
18. Operate liquid oxygen converter system test stands, pressure suit leakage, and suit control system test stands	**1**	----	1
19. Assemble equipment for, rig, secure, and release aerial delivery cargo	**1**	1	----
20. Operate instruments used in the testing of oxygen, including water vapor indicators, halide detectors, and oxygen analyzers	**1**	----	1
21. Test liquid oxygen converter systems for delivery pressure, flow rates, and venting rates	**1**	----	1
22. Operate liquid oxygen pumps, evaporation units, and manifolds used for converting liquid oxygen to high pressure gaseous oxygen	**1**	----	1
23. Test pressure suits	**1**	----	1
24. Test pressures and flows affecting pressure suit operation	**1**	----	1
102 MAINTENANCE AND/OR REPAIR			
1. Observe prescribed safety precautions and procedures in the handling, maintenance, and repair of:			
a. Parachutes and survival equipment	**3**	3	----
b. Pressure suits and oxygen breathing equipment	**3**	----	3
2. Maintain, service, inspect, and recharge oxygen cylinders	**3**	----	**3**

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
102 MAINTENANCE AND/OR REPAIR—Continued			
3. Fit, modify, clean, and test oxygen masks. Conduct tests on all available types of oxygen regulators, including test stand tests	3	----	3
4. Remove, charge, test, and replace oxygen emergency assemblies	3	----	3
5. Service CO_2 life raft systems used in aircraft and make preflight checks	3	3	----
6. Perform minor repairs to parachutes and component parts	3	3	----
7. Make changes and repairs to flight clothing and personnel protective and survival equipment	3	3	----
8. Repair and maintain:			
a. Safety belts and shoulder harnesses	3	3	----
b. Air survival kits including arctic and tropic	3	3	----
9. Inspect, test, and install safety belts and shoulder harnesses	3	3	----
10. Install standard snap fasteners and grommets, and install and repair slide fasteners	3	3	3
11. Recognize stains most frequently found in parachutes and take appropriate corrective action	3	3	----
12. Use tools required in the maintenance and repair of:			
a. Parachutes and survival equipment	3	3	----
b. Pressure suits and oxygen breathing equipment	3	--	3
13. Time and adjust standard sewing machines	3	3	3
14. Maintain, replace parts, repair, and lubricate standard type sewing machines	3	3	3
15. Remove, test, and replace aviator's breathing oxygen cylinders, lines, connectors, valves, and type regulators	3	----	3
16. Identify, and use as appropriate, fabrics, tapes, webbings, rubberized materials, fasteners, needles, and all components of:			
a. Parachutes and survival equipment	3	3	----
b. Pressure suits and oxygen equipment	3	----	3

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
102 MAINTENANCE AND/OR REPAIR—Continued			
17. Replace liquid oxygen converter systems including lines, connectors, valves, and gages in aircraft and conduct authorized maintenance	2	----	2
18. Maintain liquid oxygen transfer equipment	2	----	2
19. Perform authorized repairs and overhaul of all types of oxygen regulators and components	1	----	1
20. Maintain liquid oxygen pumps	1	----	1
21. Inspect, service, and repair all pressure suit equipment including harnesses, flotation jackets, helmets, and control systems	1	----	1
22. Remove, test, and replace composite disconnects and pressure suit control systems	1	----	1
23. Operate and maintain CO$_2$ recharge equipment	1	1	----
24. Make changes and repairs to pressure suits	1	----	1
25. Maintain and calibrate oxygen regulator, pressure suit control system, and portable pressure suit test stands	1	----	1
26. Issue local shop instructions on sewing machine maintenance	1	1	1
27. Determine needs, arrange for, and supervise instruction of personnel engaged in maintenance and repair of:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
103 ADMINISTRATIVE AND/OR CLERICAL			
1. Use NavAer publications index to locate, identify, and obtain technical publications	3	3	3
2. Instruct personnel in the use of:			
a. Parachutes and aviation survival equipment	2	2	----
b. Breathing oxygen and oxygen equipment	2	----	2
3. Prepare required records and reports of inspection and tests, and/or packing of the following:			
a. Parachutes and aviation survival equipment	1	1	----
b. Breathing oxygen and oxygen equipment	1	----	1

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
103 ADMINISTRATIVE AND/OR CLERICAL—Continued			
4. Maintain current files of applicable manuals, training courses, and technical publications concerning the operation and maintenance of:			
a. Parachutes and aviation survival equipment	1	1	----
b. Breathing oxygen and oxygen equipment	1	----	1
5. Instruct and supervise personnel engaged in the maintenance of:			
a. Parachutes and aviation survival equipment	1	1	----
b. Breathing oxygen and oxygen equipment	1	----	1
6. Assign personnel in the maintenance and repair of:			
a. Parachutes and survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
c. Pressure suits and their accessory clothing and control systems	C	----	C
7. Use allowance lists, parts catalogs, and forms in requisitioning, salvage, and survey of:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
8. Organize and administer a parachute loft or repair facility for:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
200 EXAMINATION SUBJECTS			
201 OPERATIONAL			
1. Safety precautions and procedures to be observed in the handling and stowage of:			
a. Oxygen and related equipment	3	----	3
b. CO_2 and related equipment	3	3	----
2. Procedures for inspecting, rigging, packing, handling, stowing, and issuing all types of personnel parachutes	3	3	----
3. Symbols and terms used on blueprints and drawings	3	3	3

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
201 OPERATIONAL—Continued			
4. Nomenclature, types, component parts, materials, and construction of parachutes	3	3	----
5. Procedures for inspecting, fitting, packing, and stowing all types of standard aviation protective clothing and survival equipment	3	3	----
6. Methods of inspecting, packing, handling, stowing, and issuing all types of air survival kits, including arctic and tropic	3	3	----
7. Procedures for operating regulator test stands	3	----	3
8. Ground crew check procedures on oxygen breathing equipment installed in aircraft	3	----	3
9. Dry locker procedures	3	3	----
10. Instruments used in determining temperature and relative humidity	3	3	----
11. Test procedures for standard aviation protective clothing and survival equipment	3	3	----
12. Procedures and safety precautions for operating liquid oxygen transfer equipment from storage tanks to transfer trailers and from trailers to aircraft converter systems	2	----	2
13. Construction of various types of lift webs and sling assemblies for use on cargo to be dropped with aerial delivery parachutes	2	2	----
14. Procedures for making emergency parachute jumps and use of standard aviation survival equipment under emergency conditions	2	2	----
15. Method of rigging for transporting and dropping air survival kits including arctic and tropic	2	2	----
16. Nomenclature, types, component parts, materials, and construction of various liquid oxygen converter systems	2	----	2
17. Use of vacuum pumps for evacuation of annular spaces in liquid oxygen storage and transfer equipment	2	----	2
18. Instruments used in testing oxygen including water vapor indicators, halide detectors, and oxygen analyzers	1	----	1

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	PRS	PRM
201 OPERATIONAL—Continued			
19. Procedures for testing liquid oxygen converter systems for delivery pressure, flow rates, and venting rates	1	----	1
20. Use of liquid oxygen pumps, evaporation units, and manifolds used for converting liquid oxygen to high pressure gaseous oxygen	1	----	1
21. Test procedures for pressure suits	1	----	1
22. Pressures and flows affecting pressure suit operation, including flow correction for other than standard conditions	1	----	1
23. Use of oxygen regulator and pressure suit control system test stand and portable pressure suit test kit	1	----	1
24. Equipment and techniques used to ready and release aerial delivery cargo	1	1	----
202 MAINTENANCE AND/OR REPAIR			
1. Safety precautions to be observed in the operation, maintenance, and repair of:			
a. Parachutes and aviation survival equipment	3	3	----
b. Breathing oxygen and oxygen equipment	3	----	3
2. Procedures for servicing, inspecting, recharging, and maintaining oxygen cylinders	3	----	3
3. Procedures for maintaining, fitting, modifying, cleaning, and testing oxygen masks	3	----	3
4. Procedures for removing, charging, testing, and replacing emergency oxygen assemblies	3	----	3
5. Procedures for servicing CO_2 life raft systems used in aircraft	3	3	----
6. Procedures for recharging CO_2 cylinders	3	3	----
7. Tensile strengths, durability, and other properties and general characteristics of materials currently used in:			
a. Parachutes and aviation survival equipment	3	3	----
b. Breathing oxygen and oxygen equipment	3	----	3
8. Standard procedures used in repair of parachutes and aviation survival equipment	3	3	----

	Qualifications for Advancement in Rating	*Applicable Rates*		
		PR	PRS	PRM
202	MAINTENANCE AND/OR REPAIR—Continued			
	9. Procedures for repairing and maintaining:			
	a. Safety belts and shoulder harnesses	**3**	3	----
	b. Air survival kits including arctic and tropic	**3**	3	----
	10. Procedures for testing and installing safely belts and shoulder harnesses	**3**	3	----
	11. Types, styles, and sizes of fasteners and grommets used in:			
	a. Parachutes and aviation survival equipment	**3**	3	----
	b. Breathing oxygen and oxygen equipment	**3**	----	3
	12. Methods used to identify stains on parachutes and corrective action required	**3**	3	----
	13. Care and use of tools used in the maintenance and repair of:			
	a. Parachutes and survival equipment	**3**	3	----
	b. Pressure suits and oxygen breathing equipment	**3**	----	3
	14. Nomenclature and methods of servicing and timing standard sewing machines	**3**	3	3
	15. Procedures for maintaining and repairing standard sewing machines	**3**	3	3
	16. Procedures for removing, testing, and replacing aviators' breathing oxygen cylinders, lines, connectors, valves, and type regulators	**3**	----	3
	17. Procedures for replacing liquid oxygen converter systems including lines, connectors, valves, and gages in aircraft	**2**	----	2
	18. Regulations governing changes and repairs to flight clothing and personnel protective and survival equipment	**2**	2	----
	19. Procedures for servicing, inspecting, and maintaining CO_2 equipment	**1**	1	----
	20. Procedures for authorized repairs and overhaul of all current type oxygen regulators and components	**1**	----	1
	21. Procedures for inspecting and maintaining oxygen breathing and liquid oxygen equipment	**1**	----	1

Qualifications for Advancement in Rating	*Applicable Rates*		
	PR	**PRS**	**PRM**
202 MAINTENANCE AND/OR REPAIR—Continued			
22. Procedures for inspecting, servicing, and repairing all pressure suit equipment including harnesses, flotation jackets, helmets, and control systems	1	----	1
23. Procedures for removing, testing, and replacing composite disconnects and pressure suit control systems	1	----	1
24. Methods of estimating supplies and equipment required in the maintenance and repair of:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
203 ADMINISTRATIVE AND/OR CLERICAL			
1. General content and use of NavAer Publications Index	3	3	3
2. Types and purpose of records, logs, and reports required for:			
a. Parachutes and aviation survival equipment	2	2	----
b. Breathing oxygen and oxygen equipment	2	----	2
3. Procedures for requisitioning, stowing, custody, and issuance of, and accounting for material used in:			
a. Parachutes and aviation survival equipment	2	2	----
b. Breathing oxygen and oxygen equipment	2	----	2
4. Regulations governing changes and repairs to pressure suits	1	----	1
5. Types, purpose, and use of technical publications concerning the operation and maintenance of:			
a. Parachutes and aviation survival equipment	1	1	----
b. Breathing oxygen and oxygen equipment	1	----	1
6. Organization, function, and administration of a parachute loft or repair facility for:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C

Qualifications for Advancement in Rating	Applicable Rates		
	PR	PRS	PRM
203 ADMINISTRATIVE AND/OR CLERICAL—Continued			
7. Superivision and training of personnel in the care and use of:			
a. Parachutes and aviation escape, evasion, and survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
8. Organization and administration of work assignments in the maintenance and repair of:			
a. Parachutes and aviation survival equipment	C	C	----
b. Breathing oxygen and oxygen equipment	C	----	C
c. Pressure suits and their accessory clothing and control systems	C	----	C

300 PATH OF ADVANCEMENT TO WARRANT OFFICER AND LIMITED DUTY OFFICER

Parachute riggers advance to Warrant Aviation Operations Technician and/or Limited Duty Officer Aviation Operations. (See page iv-c of *Quals Manual.*)

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